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IMPRIMÉ AU DANEMARK
ANDELSBOGTRYKKERIET I ODENSE

Henri HELDT

1891—1956

M. Henri HELDT n'est plus.

Né le 31 décembre 1891 à Uzerche (Corrèze) Henri HELDT fit ses études secondaires à Paris puis enseigna à Concarneau où il put s'initier aux recherches de biologie marine, en fréquentant le laboratoire du Collège de France.

Mobilisé en 1914, il participa aux batailles de la Marne et de la Somme: il y fut blessé à deux reprises. Cité à l'ordre de l'armée en 1915, pour sa belle conduite au front, il reçut la médaille militaire, la croix de guerre avec palme et la croix de guerre belge avec palme.

Après les hostilités on le retrouva à la Faculté des Sciences de Paris où il obtint sa licence ès-sciences.

En 1920 il entra à l'Office Scientifique et Technique des Pêches Maritimes, dès la création de cet organisme. Il effectua deux campagnes de recherches à bord de la "Perche" en Atlantique et en Méditerranée, plusieurs missions à bord de dirigeables et d'avions pour repérage des bancs de poissons. Il prit alors la Direction de la Station Aquicole de Boulogne-sur-mer.

Ses travaux ont porté principalement sur le hareng des Small's et de la Mer du Nord, sur le thon rouge, les courants de marée du "Sandettié".

En 1924 il fut nommé Directeur de la Station océanographique de Salammbô en Tunisie où il est resté 29 ans, jusqu'en décembre 1953.

Il créa de toutes pièces la Station océanographique installant des laboratoires, des aquariums, organisant un musée de pêche, montant une bibliothèque riche de dix mille volumes et assurant la publication des Annales, du Bulletin, des Notes de la Station océanographique de Salammbô.

Il se spécialisa dans l'étude du thon rouge, rédigeant de nombreuses notes, très documentées, dans le Bulletin de la Station et dans les "Rapports et Procès-Verbaux des Réunions de la Commission Internationale pour l'Exploration scientifique de la Mer Méditerranée"; il était d'ailleurs rapporteur de la question du thon auprès de cette Commission Internationale; qui publia sous sa signature dix rapports représentant la somme de nos connaissances sur cette espèce.

Il apporta en outre d'excellentes contributions à l'étude biologique des poissons des étangs, à celle des crustacés, à l'ostréiculture, à la spongiculture, à l'installation des aquariums, au fumage du poisson ....

Mettant en valeur ses qualités scientifiques et maritimes, il effectua de nombreuses missions en mer, à bord de navires de la Marine Nationale, du Navire Océanographique "Président-Théodore-Tissier" et de bateaux de pêche.

Ses services furent honorés par la France et le Danemark: il était en effet Chevalier du Mérite Maritime, Officier d'Académie, et Chevalier de l'Ordre Royal de Danebrog.

Il a participé à plusieurs Assemblées plénières du Conseil

International pour l'Exploration de la Mer: à Copenhague, Edimbourg, Amsterdam; ses interventions faites avec une souriante bonhomie y étaient fort appréciées.

Au nom de tous ses amis j'adresse un dernier adieu à Henri HELDT, et mes condoléances émues à sa dévouée collaboratrice Madame le Professeur HELDT et à sa famille.

P. Desbrosses

Editorial Notice

Statistical News Letters

No. 1: Herring – North Sea, 1955

ATTENTION is invited to a new series in the Council's publications, the first number of which appeared in August last.

The purpose of the series is to provide statistical information on the most pressing of the Council's affairs earlier and, if necessary, in greater detail than is normally done through the *Bulletins Statistiques.*

The data presented in the first of the *Statistical News Letters* relate to the quantities of herring caught by various types of gear, and the number of hours of fishing, in each statistical rectangle (1° of longitude by 30′ of latitude) in each month of the year. The figures for each country are tabulated separately.

Copies of the News Letters are to be had on application to the Secretary General, ICES, Charlottenlund Slot, Charlottenlund, Denmark, price 5 Kr. per copy, plus postage.

International Fisheries Convention 1946: Report of the *Ad Hoc* Committee Established at the Fourth Meeting of the Permanent Commission, September 1955[1)]

Preface

In September 1955, the Permanent Commission of the International Fisheries Convention of 1946 decided to set up a Committee to consider and report on the effect of mesh sizes and size limits of fish in relation to the objectives of the Convention. This Report was considered by the Commission at their Fifth Meeting in May 1956, and the recommendations of the Committee are now under study by the Contracting Governments to the Commission.

Although the Report is intended primarily to enable the Commission to fulfil its own responsibilities, the work undertaken in its preparation may be regarded as of fundamental importance to fishery research in general, and the International Council for the Exploration of the Sea have agreed that the Report should be printed verbatim in the *Journal du Conseil*. The courtesy of the International Council for the Exploration of the Sea in this respect is greatly appreciated by the Permanent Commission.

K. SUNNANÅ,
President,
Permanent Commission of the International
Fisheries Convention of 1946.
Bergen, 11. April 1957

Introduction to the Report

When left alone, all the different forms of life in nature will tend to establish a balance between themselves. The struggle for food and space will force a species to keep its individual numbers on a level which is in

[1)] Issued from the Office of the Commission. London, September, 1956.

accordance with the possibilities of existence. However, this balance can be brought to disorder by human activities.

When the human population on our globe was few in number, the wild plants and animals provided sufficient food for them. But as men increased in number it became necessary to cultivate the soil and to breed animals, in order to procure the necessary food.

The philosophy of cultivating and conserving was developed and accepted many thousands of years ago as far as the natural products of the land were concerned, but it was not so when we turn to the resources of the sea. The oceans kept their riches in darkness; now and then these vast resources were exposed to the human eye, and as all fishes in the sea could not be counted or caught, they seemed to be limitless when measured against the poor effectiveness of primitive gears and the restricted demand.

The problems of cultivating and conserving sea life were born in our time. It is in our time that increasing demand for food from the sea and a very rapid development in fishing techniques have given mankind an alarming experience that the apparently limitless resources of the sea can, in fact, be over-exploited. For some time past it has been known that sea animals like whales and seals were vulnerable and could be depleted, and more recently the North Sea has proved that even fish populations can be put out of balance by human activity.

In the years before World War I, the fish stocks of the North Sea had begun to show signs which could be explained as a result of intensive fishing. The catch per unit of effort decreased year by year. The size of the fish became small. During the war years, the stocks got a rest, and when the fishing vessels started their work after the war, the effect of the war-time protection was obvious. The vessels carried ashore rich catches of big and valuable fish. The duration of these happy circumstances was not long; very soon the catches declined and the size of the fish diminished. More work, longer time, had to be used to get a full load.

A common understanding of the seriousness of the situation brought the nations involved together, and through long and repeated discussion an "Operation North Sea" was framed. Reluctance and hesitation, however, still for a long time kept the project floating in the air. But after World War II, when the North Sea had again shown — even more clearly — that human activity counted, a pair of feeble wings called responsibility carried the 1946 Convention safely to the ground. In the Permanent Commission of the Convention, the nations from southern and northern Europe could now exchange views and opinions on the problems of the North Sea, but as different as were the climate and the habits and the structure of the fishing industries, so also were the interests and claims. It took years to agree on rather small steps forward. But even if the progress may seem to have been slow, no time has in fact been wasted. The borders between the countries are real and languages are different, and above all a basis for understanding on an international level was lacking.

At the meeting in London in 1955 the Permanent Commission decided to try to establish such a basis, and started by asking a working group of specialists some basic questions. The intuition and knowledge with which

these questions were formulated were essential for the success of the working group, and enabled the answers to have a value of a general nature. *They will most certainly serve as leading principles for all future work in fishery regulation.*

For these results we are in debt to all the men who for years have been working at sea and on land on the problems of exploitation of the sea resources. A number of names deserve to be mentioned here. When only Ray BEVERTON's name appears in this introduction to the *ad hoc* Committee's report it is because the bulk of the work of the Committee rested upon him and because his intensive work made it possible to present the report within a period of 7 months.

Bergen. August 1956

G. ROLLEFSEN,
Chairman

International Fisheries Convention, 1956: Fifth Meeting of the Permanent Commission: Report of the *ad hoc* Committee

A. Terms of reference

At the meeting in September 1955, the Permanent Commission resolved to establish an *ad hoc* Committee of the Commission (under Rule XIX) under the chairmanship of the Vice-President, consisting of one scientist nominated by each Delegation desiring to participate, with the terms of reference set out below: —

"That the terms of reference of the Committee shall be: —

(a) to receive and report on information concerning the 50% release lengths for different trawl cod-end meshes, of fish of the species listed in Annex II to the Convention;

(b) to receive and report on available information concerning the effects upon the stocks, both immediate and long-term, of applying various minimum cod-end mesh sizes;

(c) to consider the minimum sizes of fish set out in Annex II in relation to these results and to advise whether any alterations or additions are desirable in this Annex or in Article 6 of the Convention; and

(d) to seek the co-operation of the International Council for the Exploration of the Sea in the discharge of their remit."

At the meeting the Delegations were asked to nominate representatives to the *ad hoc* Committee.

The majority of the member countries were able to do so, some of them reserving their rights to make changes in their nominations at a later date. A few of the Delegations found it impossible at the time to nominate members to the Committee.

B. Meetings

The *ad hoc* Committee has held four meetings, as follows: —

1st Meeting: September 1955, in London, in connexion with the Permanent Commission Meeting.

2nd Meeting: October 1955, in Copenhagen, during the ICES Meeting.
3rd Meeting: March 1956, in Biarritz, in connexion with the ICNAF Meeting.
4th Meeting: May 1956, in London, immediately before the Permanent Commission Meeting.

Delegates from Belgium, Denmark, France, Federal German Republic, Netherlands, Norway, Poland, Sweden, and the United Kingdom were present at the last meeting, when this report was prepared.

Details of the attendance and proceedings at each meeting will be presented in a separate report to the Permanent Commission.

C. Scope of report

It is possible to offer a report on most of the questions put to the Committee. The subject matter is considered under six headings, as follows: —

Part I: Selectivity of meshes.
Part II: Assessment of long-term effects of applying various cod-end mesh sizes.
Part III: Assessment of immediate effects of applying various cod-end mesh sizes.
Part IV: Report on size limits in relation to the above results.
Part V: Alterations or additions to Annex II or Article 6 of the Convention, proposed by member countries.
Part VI: Recommendations for further research.

It should be noted here that the results presented in this report refer only to species and fisheries within the 80 mm. Convention area and are based on the latest information available to the Committee at the time of their last meeting (May 1956).

PART I

D. Selectivity of trawl and seine nets

D. 1. The first of the tasks listed in A.1 is: —

"to receive and report on information concerning the 50% release lengths for different trawl cod-end meshes, of fish of the species listed in Annex II to the Convention".

A review has been made by the Committee of all available data, both published and unpublished, on the selectivity of cod-ends of sisal and manila trawls, of cotton and hemp trawls, and of cotton seines, for six major species of fish in the fisheries covered by the 80 mm. mesh convention. These species are: plaice, cod, hake, sole, haddock, and whiting. It has not been possible, in this report, to deal with the selectivity of synthetic fibre meshes, on which some data are now becoming available.

D. 2. It is known from experimental data that as the size of the cod-end mesh of trawls or seines is increased, fewer of the smaller fish entering the net are retained by the meshes of the cod-end. This selective action of the cod-end is not, however, sharp; and it is found that the percentage

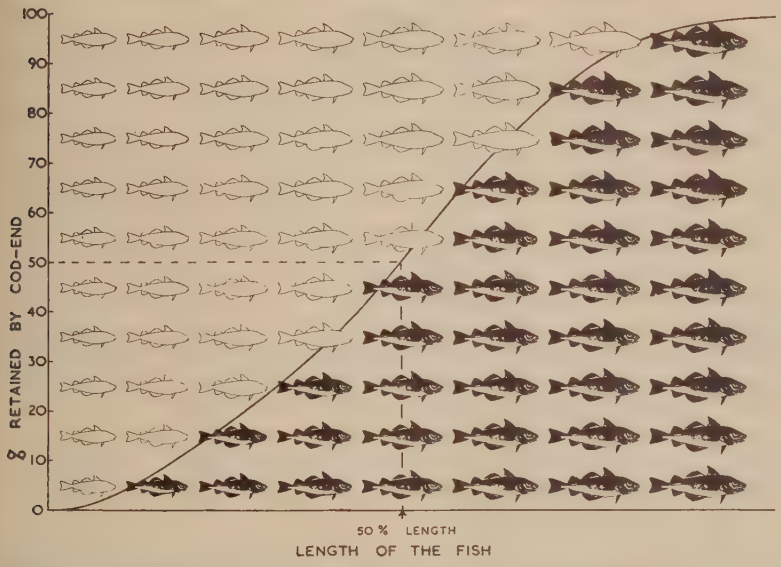


Figure 1. Diagram illustrating a mesh-selection curve and the 50% retention length. The relative number of shaded to unshaded fish at each length indicates the proportion retained in the cod-end.

of fish of each length that are retained increases over a range of length until, above a certain size, retention is complete.

When data of the percentage retention are plotted against length of fish, the points usually lie on a smooth ascending curve, called a *selection curve*. A typical example is shown in Figure 1, in which the unshaded fish represent those which escape through the cod-end and the shaded fish those which are retained. As a convenient index of the selectivity of a particular size of mesh it is usual to take the length of fish at which 50% are retained in the cod-end and 50% escape. This is called the *50% retention length* (= 50% release length), and corresponds to the mid-point of the selection curve. The 50% retention length is shown by the broken lines in Figure 1.

Experiments have shown that, over a wide range of mesh sizes, there is a closely proportional relation between mesh size and 50% retention length. This relation can be expressed as

$$50\%\text{ retention length} = \text{constant} \times \text{mesh size}$$

or

$$\frac{50\%\text{ retention length}}{\text{mesh size}} = \text{constant}.$$

It follows that when the numerical value of this constant (called the *selection factor*) for a particular species of fish has been determined by experiment, then the 50% retention length for that species of any specified mesh size can be calculated.

Table 1

Selection factors

$$\text{Selection factor} = \frac{50\%\text{ retention length (cm.)}}{\text{mesh size (cm.)}}$$

Species	Trawl		
	Manila and Sisal	Cotton and Hemp	Cotton Seine
Plaice	2·2	(2·2)	(2·2)
Sole	3·4	(3·4)	(3·4)
Haddock.....	3·2	(3·5)	3·9
Cod	3·0 to 3·5	–	–
Hake	3·5 to 4·2	3·6 to 4·2	–
Whiting.....	3·4 to 4·0	4.1	4·1

Notes: —

Plaice,Sole There are few data for cotton and hemp trawls and seines; the selection factors in brackets were agreed as provisional values.

Haddock Factor for cotton and hemp based on such few data as exist and analogy with trawl values for whiting.

Cod Range of values quoted owing to lack of experimental data.

Hake Data variable; a selection factor of 3·8 was agreed as a provisional working figure for manila and sisal trawls, and 4·0 for cotton and hemp trawls.

Whiting Manila and sisal trawl data variable; a selection factor of 3·7 was agreed as a provisional working figure.

D. 3. Table 1 presents values of selection factors, for the six species listed in D.1 above, which were agreed by the Committee on the basis of the available data.

For certain species and gears it was found that data were few or absent; for some others the estimates of the selection factors from different experiments were rather variable. Some of this variability was probably due to real differences in the ability of the fish themselves to escape through the meshes, according to the grounds and season at which the experiments were performed. In cases where it was found that the various estimates of the selection factors were reasonably similar, a single average value is given in Table 1; otherwise, a range of values is quoted.

Some further comments are given below the table.

D. 4. For easy reference, Table 2 gives the 50% retention lengths of various mesh sizes (trawl and seine) for the six species under consideration, calculated from the selection factors of Table 1. The present international size limits are also shown.

D. 5. In addition to the 50% retention lengths, it is sometimes necessary to know the range of length of fish over which partial retention occurs, called the *selection range*.

The selection range is more variable and more difficult to determine experimentally than is the selection factor, but the data reviewed by the Committee enable approximate estimates to be given in some cases. These are given in Table 3. In this table the range is expressed as the span of length to be subtracted from the 50% length to give the 25% retention length, or added to the 50% retention length to give the 75% retention length, respectively.

Table 2

50% retention lengths (cm.), cod-end mesh sizes (mm.), and size limits

Mesh Size (mm.)	Plaice Size Limit = 25 cm. s. f. = 2·2 (all gears)	Sole Size Limit = 24 cm. s. f. = 3·4 (all gears)	Haddock Size Limit = 27 cm. Trawl: Sisal and Manila s. f. = 3·2	Haddock Trawl: Cotton and Hemp s. f. = 3·5	Haddock Trawl: Seine s. f. = 3·9	Cod Size Limit = 30 cm. s. f. = 3·0	Cod Size Limit = 30 cm. s. f. = 3·5	Hake Size Limit = 30 cm. s. f. = 3·5	Hake Size Limit = 30 cm. s. f. = 4·2	Whiting Size Limit = 20 cm. Trawl (Sisal and Manila) s. f. = 3·4	Whiting Trawl (Sisal and Manila) s. f. = 4·0	Whiting Trawl (Cotton and Hemp) Seine s. f. = 4·1
60	13·2	20·4	19·2	21·0	23·4	18·0	21·0	21·0	25·2	20·4	24·0	24·6
65	14·3	22·1	20·8	22·8	25·4	19·5	22·8	22·8	27·4	22·1	26·0	26·6
70	15·4	23·8	22·4	24·5	27·3	21·0	24·5	24·5	29·4	23·8	28·0	28·7
75	16·5	25·5	24·0	26·2	29·2	22·5	26·2	26·3	31·5	25·5	30·0	30·8
80	17·6	27·2	25·6	28·0	31·2	24·0	28·0	28·0	33·6	27·2	32·0	32·8
85	18·7	28·9	27·2	29·8	33·2	25·5	29·8	29·8	35·6	28·9	34·0	34·8
90	19·8	30·6	28·8	31·5	35·1	27·0	31·5	31·5	37·8	30·6	36·0	36·9
100	22·0	34·0	32·0	35·0	39·0	30·0	35·0	35·0	42·0	34·0	40·0	41·0

s. f. = selection factor, relating 50% length to mesh size $\left(\text{s. f.} = \frac{50\%\text{ length (cm.)}}{\text{mesh size (cm.)}}\right)$

An example of the use of Table 3 to determine the selection range is as follows. Suppose it is wished to determine the selection range of an 80 mm. trawl cod-end (sisal or manila) for haddock. From Table 2 the 50% retention length is 25·6 cm.; from Table 3 it can therefore be calculated that 25% of the fish of length 25·6 – 2·4 = 23·2 cm. are retained, and that 75% of the fish of length 25·6 + 2·4 = 28 cm. are retained.

It should be noted that the range of length between the 25% retention length and the 75% retention length is not the full extent of the selection range, since a small percentage of fish smaller than the 25% retention length are retained and a small percentage of fish larger than the 75% retention length escape. The Committee did not feel that precise estimates of the total range of selection could be given, but as a rough guide it could be taken as about twice the range between the 25% and 75% retention lengths.

Table 3

Selection ranges

Species	Length (cm.) to be subtracted from, or added to, the 50% retention length to give the 25% and 75% retention lengths: Trawl	Seine
Plaice	1·2	–
Sole	1·5	–
Haddock	2·4	3·0
Cod	2·5	–
Hake	3·0	–
Whiting	2·2	3·5

The table gives the range of length of fish (cm.) to be subtracted from, or added to, the 50% retention length to give the 25% and 75% retention lengths, respectively. No distinction is made between trawls made of various materials since no significant differences of range could be established from the data available.

D. 6. Summary. The Committee wish to draw attention to the following outstanding features of the results quoted in Tables 1 and 2: —

(a) There are large differences between the selection factors for certain species, probably due primarily to difference in the shape of fish. Consequently, any one size of mesh will release different species at different lengths.

(b) For some species, the selection factors are different for different gears. Consequently, in a fishery where different gears, or gears made of different materials, are used to catch the same species of fish, the mesh size of each type of gear would need to be different if it is intended that they should have *equivalent selectivity.*

PART II

Assessment of Long-Term Effects of Applying Various Cod-End Mesh Sizes

E. Introduction

E. 1. One effect of an increase of mesh size is to allow fish to grow to a larger size before they enter the catch.

E. 2. The course of events following such an increase can be understood by considering the fate of a year-class of fish from a time before it enters a fishery. At first its numbers are reduced by natural causes, but when, through growth, the fish become large enough to be retained by the fishing gear, their numbers are reduced more rapidly through the combined effect of fishing and natural deaths. Eventually, after a number of years have elapsed, the year-class has become so depleted that it no longer contributes materially to the catch.

E. 3. The number of fish caught during each year of life is greatest in the first year after the year-class enters the fishery, when the fish are most abundant, and then declines as the number of surviving fish also declines. However, each surviving fish is increasing in weight through growth, so that, although fewer older fish are caught, they are heavier individually than the younger ones. The total catch in weight obtained from the year-class throughout its life in the fishery is the sum of the catches in weight during each year of life, these being the product of the number of fish caught at each age and the average weight of fish at that age.

E. 4. If a small-meshed net is used in the commercial fisheries, then a large proportion of each year-class will be caught while still young and small. If a larger mesh is used, then the fish will be allowed to grow to a larger size before being caught, but they will be less numerous because their numbers will have been reduced by natural causes while they are growing large enough to be retained by the larger mesh. Whether the total catch in weight obtained by the large mesh will be greater than that by the small mesh depends on: —

(a) whether the increase in weight of the individual fish is sufficient to

more than compensate for the reduction in numbers of the year-class before the fish are large enough to be retained by the larger mesh;

(b) whether, after having reached the size at which they are retained by the gear, enough of the survivors can be caught before too many have died from natural causes.

E. 5. To establish this answer by practical methods would require the use, by all vessels fishing the stock, of first the small mesh and then the larger mesh, each for a sufficient length of time to measure the total catch obtained from a year-class throughout its life, which in most fish stocks is of at least 5 years duration and in some is nearer 10 years. *This is impracticable.* However, if the necessary data are available it is possible to estimate (a) and (b) above, and *predict* what would be the *long-term effect* of changing the mesh size of the gear.

F. Method of calculation

F. 1. It is evident from the above remarks that the weight of the commercial catch is determined by: —

(a) the number of young fish entering the fishing area each year, termed *recruitment;*

(b) the *rate of growth* in weight of the individual fish in the stock;

(c) the rate at which the individuals in the fishing area die from natural causes, termed *natural mortality;*

(d) the rate at which the individuals in the fished stock are caught by the fishing gear, termed *fishing mortality.*

For a given number of recruits, the natural mortality rate will determine the number of deaths before the fish grow large enough to be caught by the fishing gear, and the natural and fishing mortality rates together will determine the total number of deaths and the number caught each year after this age. The growth-rate will determine the average weight of the individuals at each age, and hence, in combination with natural and fishing mortality, will determine the total weight of fish caught each year.

F. 2. As an example of the way in which the long-term effect of an increase in mesh size can be calculated from a knowledge of these factors, let us consider a stock in which the average weight of fish in successive years of life is as follows: —

Age	Average Weight, g.	Age	Average Weight, g.
2	80	8	435
3	170	9	450
4	250	10	460
5	320	11	465
6	370	12	470
7	405	13	473
		14	475

(These data do in fact correspond roughly to the growth-rate of North Sea sole.)

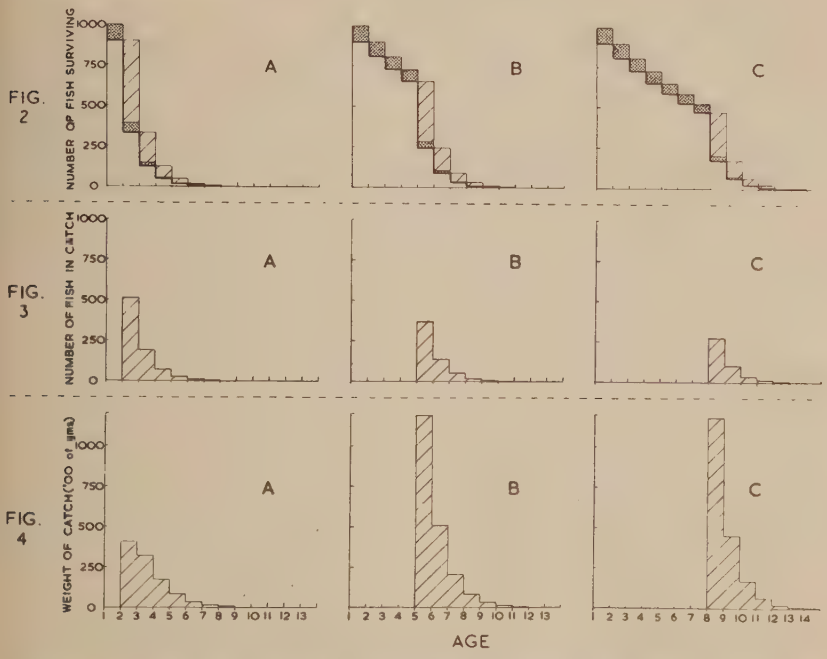
F. 3. Let us assume that recruits enter the fishing area when they are 1 year old, and that they are subject to a natural mortality rate of about 10% per year. Let us now examine the effect of fishing this hypothetical stock with three different mesh sizes, A, B, and C. Mesh A is small, and catches fish from age 2 onwards; mesh B is intermediate and starts to catch fish at 5 years old; mesh C is the largest and does not begin to catch fish until they have reached 8 years of age. These ages are determined in practice from mesh-selection experiments giving the average *lengths* at which fish are first retained by the different mesh sizes (the 50% retention lengths), these lengths then being converted to age from a knowledge of the growth in length. Let us assume that the recruits, after they enter the fishery, are subject to a total mortality rate (the combined effect of natural and fishing mortality) of 63% each year, of which nine-tenths is due to fishing and one-tenth to natural causes. This is what might be expected in a heavily fished stock.

F. 4. For illustration, let the number of recruits entering the fishing area at 1 year of age be 1,000. Now, with mesh A, the fish are present in the fishing area for one year (between ages 1 and 2) before they become liable to capture by the fishing gear. During this time they will suffer deaths due to natural causes only, at the rate of 10% per year, so that at age 2 the number of deaths will be $\frac{10}{100} \times 1000 = 100$, and the number of survivors in the stock will be $1000 - 100 = 900$. From age 2 onwards, the fish will be retained by mesh A, so that the total death rate will be 63% per year of which nine-tenths will be due to fishing and one-tenth to natural causes. Thus, of the 900 survivors at age 2, $\frac{63}{100} \times 900 = 567$ will die in the following year, of which nine-tenths ($= 510$) will be caught and one-tenth ($= 57$) will die naturally. Then the total number of survivors at age 3 will be $900 - 567 = 333$. In the next year of life, between ages 3 and 4, again 63% of the survivors will die, of which nine-tenths will be caught and one-tenth die naturally, and so on.

The results of these calculations for each year of life are given in Table 4 and histogram A of Figure 2. The total height of the histogram represents the number of fish surviving to each year of age, the cross-hatched area gives the number of fish caught, and the dotted area the numbers dying naturally.

F. 5. Turning now to mesh B, the number of recruits is reduced by natural mortality alone, at an annual rate of about 10%, for 4 years before the fish grow large enough, at 5 years of age, to be retained by the gear. The number surviving to age 5 is 656. After this age, the combined annual mortality rate of 63% applies as before, and again nine-tenths of the total deaths in each year are due to fishing. This produces histogram B of Figure 2.

F. 6. Finally, with mesh C, capture is delayed until fish have reached 8 years old, and the numbers of the year-class have fallen to 478 due to natural mortality. Thereafter, the total annual rate of 63% is again applied, producing histogram C of Figure 2.



Figures 2, 3, and 4. Diagrammatic representation of the long-term effect of mesh size on the population and catch (see Table 4).
A = small mesh, B = intermediate mesh, C = large mesh.

In Figure 2 the bold line shows the age-composition of the population corresponding to each mesh; the dotted area indicates natural deaths, and the shaded denotes number caught, in each year of life.

Figure 3 shows the number of fish caught at each age by the three meshes. The total number decreases as mesh size increases.

Figure 4 shows the weight of fish caught at each age by the three meshes. The total weight is greatest for the intermediate mesh B.

F. 7. We now consider the *number of fish* of each age caught by each of the three meshes. These are the cross-hatched areas of Figure 2 but they are shown plotted on a common base line in Figure 3. It is seen from this figure that the greatest number of fish is caught by the smallest mesh, and the least by the largest mesh. This is because the smallest mesh begins to catch fish while they are still young and numerous. The total number of fish caught by each of the three meshes is obtained by adding up the catch in each year of life; they are as follows: —

Mesh A, total catch = 809
Mesh B, total catch = 591
Mesh C, total catch = 430

Table 4

Age-group	Mesh A				Mesh B				Mesh C			
	Number of fish surviving	Catch in numbers	Average weight of fish (g.)	Weight of catch = numbers x av. wt. (100's of g.)	Number of fish surviving	Catch in numbers	Average weight of fish (g.)	Weight of catch = numbers x av. wt. (100's of g.)	Number of fish surviving	Catch in numbers	Average weight of fish (g.)	Weight of catch = numbers x av. wt. (100's of g.)
1	1000	–	–	–	1000	–	–	–	1000	–	–	–
2	900	510	80	408	900	–	80	–	900	–	80	–
3	333	189	170	321	810	–	170	–	810	–	170	–
4	123	69	250	173	730	–	250	–	730	–	250	–
5	46	26	320	83	656	372	320	1190	656	–	320	–
6	17	10	370	37	243	138	370	511	590	–	370	–
7	6	4	405	16	90	51	405	207	531	–	405	–
8	2	1	435	4	33	19	435	83	478	271	435	1179
9	1	–	450	–	12	7	450	32	177	100	450	450
10	–	–	460	–	4	3	460	14	66	37	460	170
11	–	–	465	–	2	1	465	5	24	14	465	65
12	–	–	470	–	1	–	470	–	9	5	470	24
13	–	–	473	–	–	–	473	–	3	2	473	10
14	–	–	475	–	–	–	475	–	1	1	475	5
Total		809	–	1042		591	–	2042		430	–	1903

F. 8. We now have to calculate the total *weight of fish* caught by each mesh. This is obtained by multiplying the numbers at each age by the average weight of the individuals at that age, using the growth data shown above. The final calculations are given in Table 4, and shown as histograms in Figure 4.

F. 9. The data in Figures 3 and 4 show that whereas the total *number* of fish caught decreases progressively with increase in mesh size, the total *weight* caught is greatest with mesh B, and even with the largest mesh C it is greater than with the smallest mesh A. Clearly an intermediate size of mesh (about that of mesh B) would give the greatest weight of catch from the year-class under the conditions assumed in this example; with equal recruitment each year, this would also be the greatest sustained annual catch that could be obtained from the stock by adjustment of mesh size.

F. 10. In the above example it has been assumed that 1,000 fish are recruited to the fishing area at age 2. It will be seen, however, that if some other number had been taken, say 100 or 10,000 or a million, the calculated total catch would simply have changed in proportion to the change in number of recruits. The correct *relative* change in yield with mesh size can therefore be estimated without knowing the actual number of recruits, by expressing the result as "catch per recruit". Thus in the example of Table 4, the total catch in weight per recruit by each mesh is obtained by dividing the figures of total catch given in that table by 1000, giving 104·2 g., 204·2 g., and 190·3 g., respectively. Compared with the catch obtained by mesh A, that by mesh B is 96% greater and that by mesh C 83% greater.

The importance of this procedure is that the estimation, in practice, of the actual number of fish that are recruited each year is difficult, and future recruitment can only be predicted a year or so ahead in the most favourable circumstances. If, however, it can be shown by the above method that a larger mesh would increase the catch per recruit, then it follows that the actual catches obtained by the use of that larger mesh in the fishery will be correspondingly greater than they would have been if no change in mesh size had been made; in other words, the larger mesh will enable the natural recruitment to the stock to be utilized more effectively.

The only possible circumstance in which this statement could be untrue is if the increased abundance of the stock, resulting from the use of a larger mesh, should be a direct cause of a reduction in the future level of recruitment. This is considered most improbable; on the contrary, if there should be any direct effect of stock abundance on recruitment it is likely to be in the reverse direction, so that the larger mesh would cause, not only an increase in the catch per recruit, but in the level of recruitment as well.

F. 11. The preceding paragraphs describe the essential features of the method used to calculate the long-term effect of a change in cod-end mesh size. From the example given it is evident that, in making assessments of this kind, estimates of the following population factors are needed: —

(a) the average growth rate of the individuals in the population;
(b) the natural mortality rate of the fishable stock;
(c) the fishing mortality rate;
(d) the age of entry into the fishing area;
(e) the age of entry into the catch, as determined by the size of mesh.

G. Application of the method

G. 1. It will be appreciated that the 80 mm. area presents an exceedingly complex system, with many different species of fish exploited by fleets of a number of countries using a variety of gears. Any attempt to take detailed account of all such complicating factors would be impossible at the present time. The Committee's procedure has therefore been to make, where necessary, certain simplifying assumptions when applying the method of assessment outlined above. The results thereby obtained show, nevertheless, the general effect, for each species separately, of increases in size of mesh.

Before presenting the results it is therefore important to mention the main assumptions which have been made, and the practical considerations applying to the results.

G. 2. It has been assumed: —

(a) that fishing is spread over the whole range of sizes of fish present in the stock, above the size at which fish are recruited. This is approximately true in the majority of fisheries, and some examples of the average size-composition of catches that would be expected from this assumption are given in section J. In fisheries where fishing is concentrated on the larger fish the effect of an increase of mesh size will tend to be rather greater than

is presented below, the opposite being true where fishing is concentrated on the smaller fish;

(b) that the natural and fishing mortality rates remain constant throughout the life of the fish after they have been recruited to the fishing area. It is considered that this assumption is valid for the present purposes;

(c) that the meshes of all the gears used to fish the stock have the same selectivity. In practice, the presence of vessels fishing with small-meshed gears for unprotected species may give rise to a component of fishing mortality at ages below that at which fish are retained by the size of mesh to which the assessments refer, but in the absence of any precise information it is not possible to deal specifically with this question;

(d) that an increase in cod-end mesh size has no appreciable effect on the fishing power of the gear. There is some evidence to suggest that such an effect may result, but no precise estimates of its magnitude are available for the Permanent Commission area at the present time;

(e) that there is no change in the rate of growth or in the natural mortality rate or in the level of recruitment, consequent upon an increase in the abundance of the fish stock following an increase in the size of mesh. There is, in fact, some evidence for certain species that the rate of growth would fall with increase in stock abundance and that the level of recruitment may rise, though in neither case has the effect been clearly established. Since, moreover, a fall in growth-rate and an increase in recruitment would tend to have counteracting effects, it was considered satisfactory to proceed on the assumption that neither would change, certainly for the prediction of the effect of small increases in mesh size above the present levels.

G. 3. It is well known that the number of recruits entering the stock from successive year-classes varies between wide limits for most species, and in the absence of any means of making long-term predictions of the total number of recruits for each species of fish, the calculations in this section of the report have been made on a "per recruit" basis, as explained in paragraph F. 10.

Whether the actual catches will increase in these circumstances depends on future trends in the level of recruitment. If recruitment stays at the same average level as before, the actual catches will increase in the same proportion as the calculated catch per recruit. If recruitment increases, so will the actual catches increase by a greater proportion than the catch per recruit. Conversely, if recruitment should fall, the actual catches will not increase as much as predicted from the catch per recruit, and may even decrease if the fall in recruitment is severe. But in all cases, provided the catch per recruit as calculated in this way increases and that natural recruitment is not dependent on mesh size, it follows that the actual catches after the change in mesh size will be *that much greater than would have been obtained, had no increase in mesh size been made.*

G. 4. The estimates of the various population factors used for making assessments were agreed by the Committee as the best available in the present state of knowledge of the stocks in question. Their accuracy differs, however, from one species to another. Growth is usually known with

sufficient accuracy, except perhaps in hake, while the accuracy of the selection factors for the various species has already been commented on in Part I of the report. Estimation of the fishing and natural mortality rates presents the greatest difficulty, and it is necessary to rely in some cases on indirect evidence, such as the effects of the war-time cessation of fishing, to establish whether it is reasonable to suppose that fishing mortality is large compared with natural mortality.

It can be said, in general, that of the assessments for the six species considered, those for plaice are the most reliable and those for whiting the least reliable, although allowance for this in the case of whiting has been made as far as possible. Nevertheless, extensive research on whiting is being carried out by several countries, and the conclusions for this species may need revision as further information becomes available.

G. 5. Finally, mention must be made at this stage of the importance of *size limits* when assessing the effect of increasing the size of mesh.

While the existence of a size limit in the actual fisheries will not affect in any way the application of the method outlined in section F for determining the long-term effect on the total catch of a change in mesh size, it may have an important influence on the calculated effect on the *landed* or *marketable* catch, i. e., the catch of fish above the minimum legal size. This will depend on the relation which the age of entry into the fishery bears to the age corresponding to the size limit for the species in question. Thus, if the size limit age is greater than the age at which the fish are first caught by meshes A, B, and C in the example given in section F, the effect on the weight of the *landed catch* will be different from that calculated, because a proportion of the catch with each mesh will be below the size limit and will have to be discarded at sea.

The calculations for the 80 mm. area species have been made in the first instance on the assumption that the *present international size limits remain unchanged*, and refer to changes in the catch of marketable fish as defined by those limits. However, because of the very important influence which a change in size limit may have on the long-term effect of an increase of mesh size, the question of size limits is treated in more detail in Part IV of this report.

H. Assessments of long-term effect of increase of mesh size on weight of catch

H. 1. The results of the calculations of the long-term effect on the weight of catch of increasing the cod-end mesh size from the present regulation values and maintaining the present size limits, subject to the conditions set out in section G, are summarized in Table 5. Throughout, the term "catch" refers to the landed or marketable catch, i.e., of fish above the present minimum size limits.

Table 5 shows, for the separate species: —

Column A. The estimated increase in catch per recruit that would result from the use of an 80 mm. trawl cod-end mesh (or of other gears with equivalent selectivity) expressed as a percentage of the catch per recruit with a 75 mm. mesh.

Table 5

Summary of long-term effects of applying various cod-end mesh sizes, with present size limits retained

Species	A. Percentage increase of yield with increase of trawl mesh from 75 mm. to 80 mm.	B. Estimated trawl mesh size needed to obtain maximum yield at present level of fishing intensity	C. Estimated percentage increase in yield corresponding to mesh sizes of previous columns	D. Remarks
Plaice	Small; probably less than 5 %	150 mm. or above	Certainly more than 25 %; probably nearer 100 %	Small increases in mesh above 75 mm. would have little saving effect in the main fishery areas, but would result in some saving of undersized fish on nursery grounds. A mesh size greater than 100 mm. would be needed to have a marked conservation effect in the main fishery areas.
Cod	Small; probably less than 5 %	200 mm. or above	Certainly more than 50 %; probably more than 100 %	Cod of sizes within the selection range of a 75 mm. mesh are found mainly on rough grounds where there is little fishing. Mesh sizes above 100 mm. would be needed to produce any marked conservation effect.
Hake	Small; probably about 5 %	Above 90 mm., probably in the region of 120 mm.	No precise estimate available; but possibly in the region of 50 % to 100 %	The effect of a mesh size of 80 mm. would concern mainly the saving of undersized fish, but increases above this figure would have direct conservation effect. Precise estimates are impossible because of imperfect knowledge of growth-rate and probable subdivision of stocks, but there is little doubt that considerable increases in yield could result from the use of mesh sizes larger than 75 mm.
Haddock	About 10 %	Between 90 and 120 mm.	Between 40 % and 100 %	Some of the increase in yield with meshes above 75 mm. would be due to saving of undersized fish, the present size limit being above the 50 % point of a 75 mm. trawl mesh. There is little doubt that yield would increase with mesh sizes up to about 100 mm.
Sole	Between 3 % and 10 %	Between 85 and 100 mm.	Between 10 % and 40 %	Imperfect knowledge of natural mortality rate makes accurate assessments for meshes larger than 85 mm. difficult. Even the most cautious estimate, however, indicates that yield would increase with mesh sizes up to 85 mm.
Whiting	Probably a small increase, in the region of 5 %	Between 80 and 100 mm.	Between 5 % and 30 %	Again, imperfect knowledge of natural mortality rate makes accurate assessment impossible. There is also some doubt concerning growth-rate and perhaps mesh selection. The most likely estimates are that a mesh size in the region of 85 mm. would give the greatest yield.

Column B. The estimated mesh size needed to produce the greatest catch per recruit from the species in question at the present level of fishing intensity.

Column C. The estimated increase in catch per recruit that would result from application of the mesh sizes specified in column B.

Column D. A brief summary of special features of the fishery in question, with particular reference to the reliability that can be attached to the assessments. Where assessments are uncertain, a range of values is specified, within which the actual change in yield is likely to be. It will be noted that the greatest uncertainty usually arises from lack of an accurate knowledge of the natural mortality rate. The estimates of the effect of large increases in mesh size given in columns B and C are necessarily less accurate than those of column A. The purpose of including these assessments is primarily to give an idea of the extent to which an increase of mesh size from 75 mm. to 80 mm. meets the requirements for obtaining the greatest yield from each of the species of fish concerned, at the present level of fishing intensity.

H. 2. The main conclusions to be drawn from Table 5 are that, compared with the catch per recruit with a 75 mm. trawl mesh and present size limits, and at the present levels of fishing intensity: —

(a) an increase of trawl mesh to 80 mm. would result, in the long run, in some increase in the landed catch per recruit of all species considered in this report;

(b) for plaice and cod, mesh sizes above 90 mm. would be needed in order to produce any marked increase in the catch per recruit. For both species, a mesh size of at least 140 mm. to 150 mm. would be required to obtain the greatest catch per recruit;

(c) for haddock and hake, a mesh size in the region of 100 mm. or perhaps a little larger, would be needed to obtain the greatest catch per recruit;

(d) some further increase in the catch per recruit of sole, and probably of whiting, would result from the use of a mesh size between 80 and 100 mm.

H. 3. If the present level of fishing intensity is maintained, i. e., if the amount of fishing and the fishing power of vessels and gear remains the same, the above increases in catch per recruit resulting from the use of larger meshes would produce corresponding increases in the catch per unit fishing effort, that is, in the catch per day absent from port or per hour fishing. If the fishing intensity should increase above its present level, the effect of small increases in mesh size on both the catch and the catch per unit effort would be less than is stated in Table 5.

H. 4. The above assessments refer to the average level of catch per recruit after the stocks have received the full benefit of the increase in mesh size. In practice, this would take a period of several years after the introduction of the larger mesh. Events immediately following the change in mesh size are described in Part III of this report.

J. Estimated long-term effect of increase of mesh size on size composition of catches

J. 1. Where an increase of mesh size allows more fish of marketable size to escape, there will always be an increase in the average size of fish comprising the landed catch. This will happen with an increase of trawl cod-end mesh from 75 mm. to 80 mm. in the case of sole, haddock, and whiting, but larger increases would be needed to have an appreciable effect on the average size of the fish in marketable catches of plaice, cod, and hake.

J. 2. Calculated long-term size-compositions of catches of sole, haddock, and whiting with 75 mm. and with 80 mm. trawl cod-end meshes (sisal or manila) are illustrated in Figures 5, 6, and 7. These are calculated on the basis of 1,000 fish recruited to the fishing area at a length of 20 cm., with the same assumptions as apply to the assessments of the change in weight of catch summarized in Table 5. This method of calculation enables the number of fish of each size caught by the two meshes to be directly compared, as in the examples of Figures 4 and 5.

(a) Sole (Figure 5). A 75 mm. trawl cod-end releases nearly all soles of 20 cm. and retains about half those of 25 cm.; therefore only a small proportion of the catch is below the minimum legal size of 24 cm. (indicated in Figure 5 by the vertical broken line). The size-composition of catches with a 75 mm. mesh is shown by the histogram drawn with broken lines (-----). After an 80 mm. mesh has been in use for several years and its saving effect has spread through all age-groups represented in the stock, the average size-composition of catches is shown by the histogram drawn with continuous lines (———). Despite some loss of the smaller marketable fish, the greater number of larger fish in the catches causes the total weight of the marketable catch to increase (see Table 5).

(b) Haddock (Figure 6). The 50% retention length of a 75 mm. mesh for haddock is about 24 cm. (see Table 2), and only a small proportion of fish of 20 cm. are retained. With a size limit of 27 cm., about one-fifth by weight of the total catch is undersized. The long-term effect of an 80 mm. mesh is to increase the catch of all fish above 28 cm. in length, that is, over practically the whole of the size range of the marketable catch. At the same time, the quantity of undersized fish caught is much reduced.

(c) Whiting (Figure 7). The 50% retention length of a 75 mm. trawl mesh for whiting is about 27 cm. (see Table 1), and only a very small proportion of fish smaller than 22 cm. which enter a cod-end of this size are retained by it (see Table 3); in Figure 7 these fish are ignored. Thus virtually the whole of the catch obtained with a 75 mm. mesh is above the international size limit of 20 cm. The long-term effect of an 80 mm. mesh is to decrease the catch of fish smaller than 31 cm. but to increase the catch of larger fish, which is sufficient to cause a small increase in the total weight of the marketable catch.

J. 3. As before, these assessments refer to average size-compositions of catches after the stocks have received the full benefit of the increase in mesh size. The immediate effect of an increase of mesh size on the size-composition of catches is mentioned in Part III.

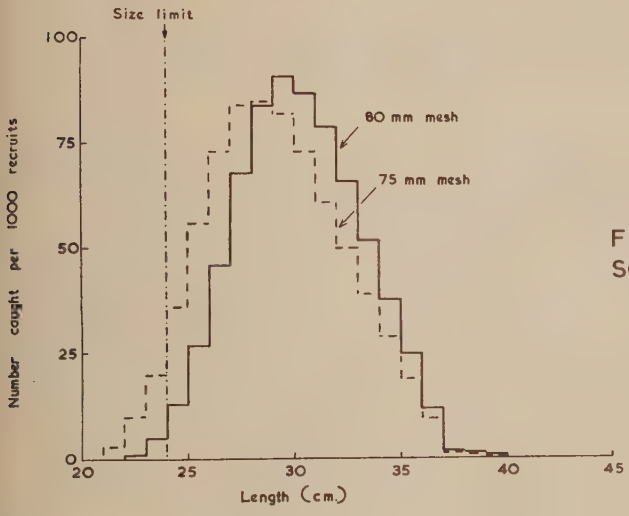


FIG. 5
SOLE

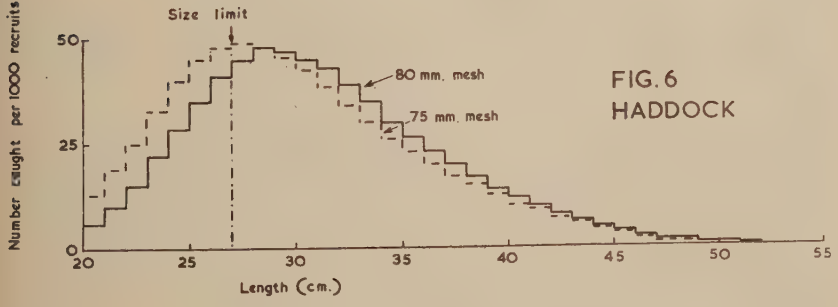


FIG. 6
HADDOCK

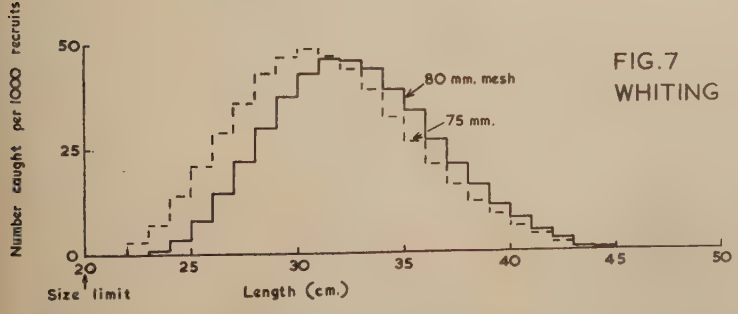


FIG. 7
WHITING

Figures 5, 6, and 7. Long-term effects of an increase in trawl cod-end mesh from 75 mm. to 80 mm. on the size-composition of catches of certain species. Broken histograms show predicted size-compositions with a 75 mm. mesh.

PART III

Immediate Effects of Applying Various Minimum Cod-End Mesh Sizes

K. Methods of assessment

K. 1. When the size of mesh used by a fleet is suddenly increased, the immediate effect is that the larger mesh releases a number of small fish which would have been caught by the smaller mesh previously used.

The larger mesh may also increase the overall fishing power of the gear, in which case the catches of fish of sizes above the selection ranges of both meshes would be greater than before. There are indications from many mesh experiments that an increase in the size of the mesh of nets tends to increase the fishing power of the gear. This result has been found in the Georges Bank haddock fishery, following an increase in mesh size by regulation. At the present time it is difficult, however, to arrive at any precise estimate of the increase in fishing power that would result from any particular increase in cod-end mesh, and it is unlikely to be the same in different species. The procedure that will be adopted here is therefore to assume in the first instance that there will be no change in fishing power.

K. 2. The immediate effect of an increase in mesh size can be further explained with reference to Figure 8. This shows the selection curves of two meshes, (a) small and (b) large. The ordinates define the percentage of fish of each length that are retained by the cod-end meshes. These curves can be derived directly from data of mesh experiments.

The immediate effect of increasing the mesh size can therefore be estimated by determining the average size-composition of the commercial catch, e. g., by market sampling, and using this, together with a knowledge of the selection curves of the existing mesh and the proposed new mesh, to predict the size-composition of the catch that would be obtained with the new mesh.

This method of calculation is shown graphically in Figure 8. The open histogram shows an hypothetical example of the length composition of a commercial catch obtained with mesh (a) above. The shaded histogram shows the predicted length composition with mesh (b). From a knowledge of the length composition of the catch corresponding to each mesh, the change in total weight of fish caught can be calculated.

K. 3. It follows from the foregoing that, unlike the long-term effect of an increase in mesh size, the *direction* of the immediate effect will always be the same (apart from any compensation due to increased fishing power); the immediate effect will always be to *cause a reduction of the total catch, compared with the catch that would have been obtained with the old mesh.* This proviso arises from the fact that if the change in mesh happened to coincide with the entry into the catch of a strong year-class, the abundance of the latter might well cause the total catch to increase despite the change in mesh size. For this reason the immediate effect of an increase in mesh size should be calculated with reference to the size-composition of the commercial catch immediately prior to the mesh change.

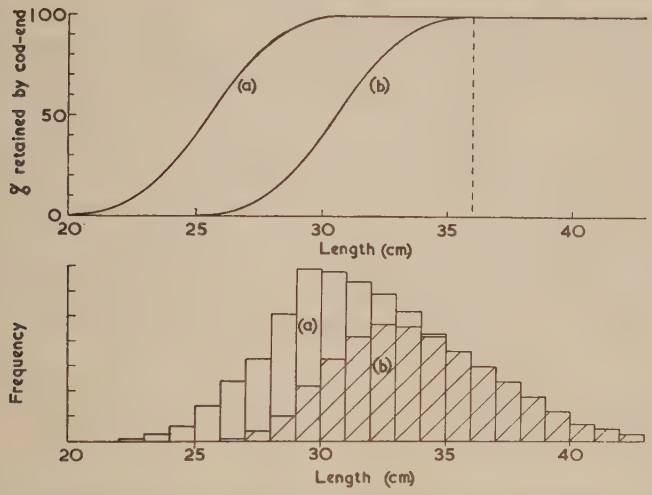


Figure 8. Illustrating the method of calculation of the immediate effect of changing the size of mesh. The upper part of the diagram shows the selection curves for two sizes of mesh, (a) small, (b) large. In the lower part, the total histogram represents the size-composition of catches obtained by mesh (a), and the shaded part that of the catches by mesh (b).

K. 4. The immediate loss referred to above does not necessarily influence the landed part of the catches. In species where the size limit is above the selection range of the larger mesh, such as in plaice and cod with mesh sizes up to 90 mm. or 100 mm., there will be no immediate effect on the landings (see para. L. 2).

K. 5. If different fleets happen to fish on different parts of the same stock so that the size-composition of their catches is not the same, an increase in mesh size will have different immediate effects on the catches of each. These can be calculated if the size-composition of the commercial catch of each is known, but at the present time the published information on this is very incomplete. The assessments given in the following section are examples showing what would have been the immediate effect of a change in mesh size in 1955 in certain British fisheries for which data are available. In general, fisheries based on parts of the stock where the fish are of a smaller average size than in these will experience a greater immediate loss, and vice versa.

L. Assessments for particular species

L. 1. The following assessments refer to a change in the cod-end mesh of manila and sisal trawls from 75 to 80 mm. and of seines from 70 mm. to 75 mm.

L. 2. Since the size limits for plaice and cod are above the selection range of an 80 mm. trawl mesh for these species, the change of mesh from

75 to 80 mm. would concern only the catches of undersized fish. Hence there would be no immediate effect on the landings due to the change in selectivity of the mesh, but if the 80 mm. mesh causes any increase in the fishing power of the gear the landings would increase temporarily to this extent.

The selection curve of an 80 mm. trawl mesh for hake only extends a few centimetres above the size limit, and the immediate effect would probably be too small to detect in the English fishery, which is used as an example.

L. 3. The three species for which an assessment of the immediate effect of the changes in mesh specified above is particularly required are therefore sole, haddock, and whiting, since these will influence directly the landed catch of each of these species.

Representative data of the size-composition of commercial catches are, at the time of writing, available for the 1955 English sole fishery, the 1955 English and Scottish whiting fisheries, and the 1955 Scottish haddock fishery.

L. 4. The results from these data are summarized in the following table, with no allowance for increase of fishing power.

Species	Fishery	Immediate Loss of Catch %
Sole	English (trawl)	7
Haddock	Scottish (trawl)	5
	Scottish (seine)	11
Whiting	English (trawl)	21
	Scottish (trawl)	24
	Scottish (seine)	23

It should be emphasized that these data refer to a particular year (1955) and to particular fisheries only. However, there is reason to believe that the figures for haddock and whiting are likely to be reasonably typical for the fisheries concerned. The sole figure is based on a year with rather higher average size than normal, and therefore the loss in normal years may be somewhat higher.

L. 5. These assessments are based on the assumption that the *size limits remain at their present level.* If the introduction of a new mesh size is accompanied by an increase or decrease in the size limits within or above the selection range of the new mesh, the immediate losses will be higher or lower respectively, than those given here.

L. 6. Something can also be said concerning the *duration* of the immediate losses. The immediate losses assessed above apply only for a short time after the introduction of the new mesh. Recovery starts at once.

An increase of 5 mm. in mesh size means, in the case of sole, haddock, and whiting, that the fish are allowed to grow a further 1·5 to 2·0 cm. before entering the catch. This growth will be accomplished in approximately half a year. Thus after this time the fish which have had the full protection of the larger mesh will start entering the catches, and after a year or so the catches will reach the level at which they would have been if the mesh size had not been increased. After two or three years following the change in mesh the yield per recruit will have nearly risen to its new steady level. Seine catches of the species concerned would take the longest time to recover fully, since a 5 mm. increase in seine mesh corresponds to a slightly greater span of length of fish than does a 5 mm. increase of trawl mesh (see Table 2.)

PART IV
Size Limits

M. Introduction

M. 1. Item (c) of the Terms of Reference of the Committee is: —

"to consider the minimum sizes of fish set out in Annex II in relation to these results (i.e., long-term and immediate effects of applying various minimum cod-end mesh sizes) and to advise whether any alterations or additions are desirable in this Annex or in Article 6 of the Convention".

M. 2. The Committee has dealt with this task in two ways: —

(a) the Chairman circulated a letter to each member country asking for opinions or specific proposals on the question of whether any alterations, additions, or removals are desirable in the list of species in Annex II or in Article 6 of the Convention, and on what scientific evidence those proposals were based. The replies have been summarized by Dr. WENT in Part V of this report;

(b) the Committee has considered in detail the probable effect of size limits in relation to the long-term and immediate results of applying various minimum cod-end mesh sizes, in the case of the six main species treated in this report; viz., plaice, cod, sole, haddock, hake, and whiting. It is this aspect of the problem with which this Part IV of the report is primarily concerned.

The Committee wish to state at the outset that it encountered many difficulties when attempting to assess the conservation value of size limits. What is offered here are certain general statements which it is thought might be of help to the Permanent Commission.

N. The conservation value of a size limit

N. 1. It is the opinion of the Committee that if the provision of a minimum legal size for fish landed is to be of any conservation value, it must have one or other of the following functions: —

(a) to discourage fishing on nursery grounds where the fish caught are mainly small in size;

(b) to cause fishermen to use the size of mesh prescribed by regulation, as an adjunct to direct enforcement by inspection of nets.

N. 2. In reviewing the function of the present size limits for the various species it is necessary to bear in mind their relation to the selectivity of meshes in each case. This information is given in detail in Table 2, but for convenience the main features of that table for 75 mm. and 80 mm. trawl meshes and 70 mm. and 75 mm. seine meshes are summarized in the following table.

Species	Present Size Limit (cm.)	50% Retention Lengths (cm.) of Trawl Cod-Ends (Sisal and Manila) 75 mm.	80 mm.	Seine Cod-Ends (Cotton) 70 mm.	75 mm.
Plaice	25	16·5	17·6	–	–
Cod	30	22·5–26·3	24·0–28·0	–	–
Hake	30	26·3–31·5	28·0–33·6	–	–
Sole	24	25·5	27·2	–	–
Haddock	27	24·0	25·6	27·3	29·3
Whiting	20	25·5–30·0	27·2–32·0	28·7	30·8

N. 3. If the function of a size limit is to protect young fish on nursery grounds, it follows that the nursery grounds must be fairly well separated from the main fishing grounds where the larger fish are found. This is the case in plaice, and the Committee agreed that the present size limit of 25 cm. for this species is of value in protecting small plaice on the nursery grounds. The same is true, though probably to a lesser degree, for the present size limits for cod and hake.

With the remaining three species, sole, haddock, and whiting, there is no clear-cut segregation of young fish on nursery grounds. Hence, in these species, the function of a size limit must be (b) above, i.e., to help to enforce the use of a regulation mesh size. The same would be true in plaice, cod, and hake if it were wished to apply to them appreciably larger mesh sizes than at present (e. g., above 90 to 100 mm. in plaice and cod, and above 85 to 90 mm. in hake).

P. Size limits as an adjunct to a mesh regulation

P. 1. It will be seen from the above table that the size limits for the three species sole, haddock, and whiting do not all bear the same relation to their 50% retention lengths for the meshes concerned. Thus, in sole and whiting the size limit is *below* the 50% retention length of both 75 and 80 mm. trawl meshes (manila and sisal), whereas in haddock it is *above*. The first question to decide is, therefore, in cases in which the provision of a size limit is thought necessary as an adjunct to the enforcement of a mesh regulation, where it should be set in relation to the selection range of the regulation mesh size. The Committee could find no really satisfactory answer to this, but would wish to draw attention to the following points.

P. 2. If a size limit is set too low in relation to the selection range of the regulation mesh, it would not only have little direct effect in helping to enforce the regulation mesh, but would be an incentive for fishermen to use meshes smaller than the legal size. From the fisherman's point of view, the size limit and the mesh regulation would seem to be contradictory. For example, suppose a size limit of 25 cm. were prescribed in conjunction with a regulation mesh having a 50% retention length greater than this, say 30 cm. This would amount to telling fishermen that, on the one hand, they can legally land a fish of 25 cm., but on the other, that they must use a mesh which is too large to catch fish of that size, at least in any quantity.

P. 3. If a size limit is set at or near the upper end of the selection range of the regulation mesh, where retention is nearly complete, it will certainly make it unprofitable for fishermen to use a smaller than legal mesh, since this would serve only to increase the catch of undersized fish which they could not land. The disadvantage, however, of such a procedure is that since the selectivity of meshes is not sharp, setting a size limit at or near the upper limit of the selection range of the regulation mesh would cause a great number of undersized fish to be unavoidably caught and rejected at sea, even by the regulation mesh. All such rejected round fish, such as haddock and whiting, would certainly die, but a certain proportion of rejected flatfish would probably live, depending primarily on how the catch is handled on deck, but in most cases this proportion is not thought to be high.

It can be said quite definitely that the effect of the wastage caused by the unavoidable capture of undersized fish with the above procedure would be to reduce very considerably the gain in catch of marketable fish that could be expected from application of a mesh regulation, in all species. In plaice, cod, and hake, some long-term increase in landed catch would still be possible, although very much less than predicted in Part II of this report. In haddock, sole, and whiting, the effect would probably be to decrease the landed catch rather than to increase it.

P. 4. It is emphasized that exactly the same considerations as in P.3 apply to the use of a size limit alone as a conservation measure, except where its function is to protect nursery areas. In all other circumstances it is probable that fishermen would use a mesh size which allowed only a small percentage, if any, of legal-size fish to escape. Again, the wastage due to the unavoidable capture and rejection of undersized fish would, in most cases, be so great that little conservation value, and perhaps definite harm, would result.

P. 5. In view of the above considerations, the Committee is of the opinion that where a size limit is thought to be essential for helping to enforce a mesh regulation, it should be set *at or near the 50% retention length for the regulation mesh.* Some wastage through rejection of undersized fish would still occur, though not to such an extent as in P. 3 and P. 4 (see also section Q).

P. 6. Special considerations apply to mixed fisheries where different protected species are caught together by the same gear. In such cases the

Committee is of the opinion that if size limits are prescribed they should each bear the same relation to the selection ranges of the gear for the species in question, except where protection of nursery grounds is concerned. If the size limit for one or more species is much lower relative to, say, the 50% retention length for that species than for the rest, there will not only be an incentive for fishermen to use a smaller than legal mesh but, if that should happen, there would be serious wastage through rejection of undersized fish of the species with a relatively high size limit.

The same considerations apply to fisheries in which an important constituent of the catch is an unprotected species (e.g., herring) for which no mesh regulation or size limit exists.

Q. The influence of size limits on the long-term effect of increasing the size of mesh

Q. 1. It was emphasized in Parts II and III that the effects of applying various cod-end mesh sizes were calculated with reference to present conditions, i.e., with the present regulation mesh sizes and size limits. For comparison, the effects on the long-term changes in the landed catches of setting a size limit at the 50% retention length of whatever mesh size is prescribed by regulation are set out below.

Q. 2. Plaice and Cod. Since the function of the present size limits in these species is primarily to protect nursery grounds, it would not be necessary for enforcement of a mesh regulation to increase them until mesh sizes in the region of 100 mm. were reached.

Q. 3. Hake. For similar reasons, no change in size limit would be needed until mesh sizes above 80 mm. were considered. With larger mesh sizes, with the size limit adjusted to the 50% retention length, the increase in landed catch would be rather less than predicted in Part II, but still considerable. No precise estimates can be made.

Q. 4. Haddock. Since the present size limit is a little above the 50% retention length of an 80 mm. trawl mesh (manila and sisal), the limit would have to be slightly *reduced* to bring it in line with the 50% retention length of such a mesh. Thus the increase in the landed catch, corresponding to an increase in trawl mesh from 75 mm. with the present size limit to 80 mm. with the lower size limit, would be a little greater than that given in Part II. It is to be noted that, without any change in trawl mesh size, a reduction of the present size limit for haddock to the 50% retention length of the present 75 mm. mesh (about 24 cm.) would increase the landed catch by reducing the wastage of undersized fish. Larger meshes, up to 100 mm., would still produce considerable increases in the landed catch per recruit of haddock with the size limits adjusted to the 50% length, but these would be no more than half to two-thirds of those quoted in Table 5 of Part II.

Q. 5. Sole. There would probably be a small increase in the landed catch with meshes up to 80 mm., although less than given in Part II. It is doubtful

whether the catch would continue to increase with meshes much larger than 80 mm.

Q. 6. Whiting. Since the present size limit is below the 50% retention lengths of the present regulation meshes, adjustment of the size limit to the 50% retention length would increase the wastage of undersized fish. It is doubtful whether further increase in mesh size, coupled with a size limit fixed at the 50% retention length, would produce any increase in the landed catch compared with present conditions. It must be remarked, however, that the present size limit of 20 cm. for whiting can hardly be regarded as having any enforcement value, even for the present regulation mesh sizes.

R. Summary of conclusions concerning size limits

The Committee would wish to draw attention to the following points: —

R. 1. Except where size limits protect nursery grounds, the greatest yield from a species is obtained by the use of the appropriate size of mesh, and *with no size limit*. While acknowledging the difficulties and limitations of direct enforcement of a mesh regulation by inspection of meshes alone, the Committee are of the opinion that the above fact should be borne in mind when methods of conservation and enforcement are considered.

R. 2. The Committee were agreed that no general abolition of size limits could be recommended at the present time. The Committee also agreed that where size limits are necessary as an adjunct to the enforcement of a mesh regulation, they should, as a rule, be set at or near the 50% retention length of the regulation mesh for the species in question, except where the protection of nursery grounds is concerned. This would allow an increase of trawl mesh to 80 mm. to produce some increase in the landed catch per recruit of all species except whiting.

R. 3. The Committee wish to couple their recommendation that size limits should be set at the 50% retention length with the plea that, notwithstanding, every effort should be made to increase the degree of enforcement of a mesh regulation by direct inspection methods. If direct enforcement is ineffective there is a danger that smaller than legal meshes would be used, with a consequent increase in the wastage of undersized fish and hence a smaller yield of marketable fish.

R. 4. The use of size limits alone as a method of conservation (except for the protection of nursery grounds) cannot be recommended. In some species it would probably cause a reduction of catch compared with present conditions.

R. 5. The Committee wish to emphasize that some of the difficulties encountered in the foregoing may be due to the fact that the present mesh regulation prescribes the same minimum size of mesh in all trawl fisheries in the 80 mm. Convention area.

PART V

Alterations and Additions to Annex II and Article 6 of the Convention

Under its terms of reference (c) the *ad hoc* Committee was asked to advise whether any alterations or additions are desirable in Annex II or Article 6 of the Convention. The following letter was accordingly sent to the delegates of the different member countries.

Bergen, den 31. desember 1955

"Dear Sir,

The Permanent Commission in September, 1955 remitted to an *ad hoc* Committee certain questions, including, *inter alia*, whether any alterations or additions were necessary in the list of species in Article 6 or Annex II of the Convention. In order to facilitate the work of the Committee it has been decided to invite members to furnish replies to the following questions as far as they relate to their countries.

(1) Are there any additional species of fish which need the type of protection afforded by their inclusion in Annex II and if so on what scientific evidence do you base your opinion.

(2) Are there any species of fish which should be removed from Annex II and if so on what scientific evidence do you base your opinion.

(3) Are there any other species of fish which should be included in Article 6 as now drafted. If so, what scientific evidence is available as to the effect of fishing this (or these) species with small-mesh nets on the stocks of species which are already included in Annex II.

Replies to this questionnaire should be sent to Dr. A. E. J. Went, 3, Cathal Bruga Street, Dublin, who has undertaken to prepare a short summary of the information provided in the various replies as a basis for a preliminary discussion of the subject at the next meeting of the Committee. It would be appreciated if a copy of any published work or works cited could be sent to Dr. Went with your reply."

Gunnar Rollefsen

Dr. A. E. J. Went, who kindly undertook to collect the replies, has now prepared the following summary of the suggestions received.

Replies to Mr. G. Rollefsen's circular letter of 11. January 1956

Replies have now been received from all participating countries except Iceland. Belgium, Ireland, Poland, Spain, and Sweden have no alterations to suggest in the list of species in either Article 6 or Annex II. Norway has no immediate change to suggest but thinks that it is desirable to await the report of the *ad hoc* Committee concerning the 50% release/retention lengths of the different cod-end meshes for fish of the species listed in Annex II. The United Kingdom at this stage does not wish to put forward any change in the list of species in Article 6 or Annex II but reserves the right to

propose the inclusion of the garfish (*Belone belone* L.) in Article 6 at a later date if that course appears to be necessary. Dr. RAMALHO of Portugal, who points out that he has no definite instructions from his Government, mentions that as Portuguese vessels do not fish in the Convention area he, personally, would not have any suggestions to make on this subject.

Denmark, France, and the Federal Republic of Germany all have suggestions to make regarding the lists of species included in Article 6 and Annex II. Denmark expresses the opinion that there is no need to include in Annex II any other commercial species of fish but emphasizes that she considers it desirable to increase the minimum size for landing of several of the species now included, namely, cod (33 cm.), haddock (32 cm.), hake (45 cm.), plaice (26 cm.), lemon sole (28 cm.), sole (25 cm.), turbot (35 cm.), and brill (33 cm.). Furthermore, in answer to the second question Denmark proposes that the whiting and the dab should be omitted from Annex II because it is not known if a size limit for these species is beneficial to the fishery as a whole. It was also pointed out that small whiting are valuable in the fisheries of some countries and that the dab is a serious competitor for food of some of the much more valuable species, viz., plaice. As to the third question, Denmark suggests that Article 6 as now drafted may well prove a hindrance to the development of new fisheries and she proposes, therefore, the addition of many other species or even genera or families of fish which may be prospective subjects for a future fishery. Alternatively, Denmark suggests that Article 6 should be redrafted as follows: —

"Notwithstanding the provision of Article 6, vessels fishing exclusively for any other species than those mentioned in Annex II, may carry on board and use nets having meshes of dimensions less than those so specified: provided that any undersized fish of the species mentioned in Annex II be returned to the sea immediately after capture. Not over 2 (?) percentage by weight of undersized fish of the species mentioned in Annex II and overlooked by sorting may be tolerated by the fishery inspector."

The reply of the Federal Republic of Germany supports the Danish proposals and it is worth while quoting the relevant portion of the German reply as follows: —

"A. The list of fish especially protected by the establishment of minimum sizes should on principle cover only species, for which biological criteria clearly reveal a necessity and worthiness of protection. Therefore, species should be removed from Annex II,

(a) for which such necessity is not scientifically proved;

(b) which have been included only in order to gain a protective effect on other species.

B. Provisions should be made designed to facilitate the inclusion of additional species, at present not in common use as human food, in the list of fish, which may be caught by mesh sizes inferior to those mentioned in the Convention, such as *Ammodytes* sp., *Gasterosteus* sp., *Gadus poutassou*, *G. esmarki*, as the demand may arise.

C. Alternatively to the above suggestion, it might be agreed that protection by minimum mesh sizes should apply only to species requiring protection

and accordingly listed in Annex II. In this case Article 6 would have to be substituted by a paragraph enforcing minimum mesh sizes for catching species enumerated in Annex II. However, in order to attain the object of the Convention, it might be useful to introduce an additional list of species, for which only minimum mesh sizes, but not special minimum fish sizes should apply. On it such species should be recorded which at present do not require protection, but fishing of which, if carried out by small meshed nets, might be expected to do considerable harm to protected species."

The French reply recommends the removal of the whiting from the list of protected species in Annex II on the grounds that there is no evidence of over-exploitation of this species and that the experience gained on the research ship "Président-Théodore-Tissier" in 1955 shows that the existing minimum mesh sizes are sufficient to safeguard whiting of marketable size. The Netherlands have no suggestions for any alterations in the list of species in Annex II but recommends, as opposed to Denmark and Germany, that the inclusion of more species in Article 6 is dangerous. The relevant extract from the Netherlands reply sums up the position adequately. It is as follows:—

"We feel that most of the commercial fish species, not mentioned in either Annex II or Article 6, need the type of protection afforded by the minimum mesh size, although for most of these species no scientific evidence is available. It is difficult to assess whether there are any other species of fish, not of commercial value now, which might become commercially important in the future and can only be caught with small-meshed gear.

We like to stress that inclusion in Article 6 of more fish species than is absolutely necessary is very undesirable. It would increase the difficulties encountered in the enforcement of the mesh regulations, most of the North Sea fisheries being mixed fisheries. Instead of the inclusion in Article 6 of more species we are of the opinion that it would be desirable to remove from Article 6 those species on which no real fishery with small-meshed gear is carried out, viz., eel and greater weever."

April, 1956 ARTHUR E. J. WENT, Dublin

The above summary reveals that some suggestions concerning size limits make no reference to the mesh size in relation to them. The Committee is of the opinion, as outlined in Part IV of this report, that recommendations concerning size limits cannot be considered without reference to mesh size, and it feels, therefore, that it can do no more than present these suggestions, as they stand, to the Permanent Commission. The Committee does, however, draw the attention of the Commission to its remarks on this subject in Part IV of this report.

A number of other proposals are contained in the summary, but the Committee has been unable to devote sufficient time in discussing them to provide the Commission with a considered view.

Finally, it must also be borne in mind that the increasing use of small-meshed nets for catching species listed in Article 6 and/or species not mentioned in Annex II certainly needs special attention.

PART VI

Recommendations for Further Research

In the course of its work, the Committee has encountered a number of gaps in the information needed to make the various kinds of assessments described in this report. The existence of many of these gaps is already generally realized, but they have perhaps taken on a greater significance as a result of the need to produce a satisfactory scientific basis for the conservation of the various fisheries within the Permanent Commission area.

The Committee therefore wishes to recommend to the Commission that investigations should be made to obtain further information on the following items: —

A. Gear selectivity and fishing power

(1) Selectivity data for cod and hake caught by manila and sisal trawls.
(2) Selectivity data for all species, covered in the Committee's report, caught by cotton and hemp trawls, both double and single braided.
(3) Selectivity data for all of these species caught by seine net.
(4) Selectivity data for all species caught with trawls and seines made of synthetic fibres.
(5) The factors other than mesh size and type of material which affect the selectivity of the gear.
(6) The effect of mesh size on the fishing power of the gear, as distinct from the effect on its selectivity.

B. Biological information

(1) Length compositions of the commercial catches by each country of all protected species.
(2) Accurate determination of growth-rate of hake, sole, whiting, and cod in different areas.
(3) The possible area subdivision of stocks of hake and whiting.
(4) The influence of stock density on growth, natural mortality, and recruitment.

C. Destruction of undersized fish

(1) Sampling and estimates of the quantity of undersized fish of all species rejected at sea on commercial vessels.
(2) The mortality of and damage to fish caught by different gears and rejected at sea; also, the effect on the survival of rejected fish of the way the catch is handled on deck.

D. Statistics of catch and effort

(1) Commercial statistics of catch and effort for all species, gears, and countries, subdivided into as small time and area intervals as possible.

An Improved Salinity and Density Meter

By

Roland A. Cox

SOME three years ago the author (1) described in this journal an apparatus for determining the density, and computing the salinity, of sea water. This apparatus has since been modified in a number of ways to make it easier to construct and use; the modified instrument, described below, is in regular use in several laboratories.

The fundamental principle of the apparatus is unchanged from that described in the earlier paper. A small float similar in density to the sea water is immersed in the sample under test; this float is then compressed until its mean density is exactly equal to that of the water, at which point it remains neutrally buoyant, neither rising nor sinking. The pressure which has been applied to bring this about is then a measure of the density of the sample. It is converted into a direct reading of salinity by automatically applying a temperature correction corresponding to the temperature of the sample, as read on a thermometer.

Design of Apparatus

In the prototype meter the float was blown from glass tubing. Glass is a very good material for springs, but it suffers from two disadvantages; it is easily broken, and it is difficult to reproduce with sufficient accuracy. After lengthy trials of different forms of construction, glass was abandoned as the material for the springs and replaced by K-Monel metal foil. This alloy has excellent spring properties combined with a good resistance to corrosion by sea water. The structure of the float finally adopted is shown in Figure 1. An annular ring of S. 80 stainless steel, with a channel-shaped cross-section, is turned on a lathe. Two disks of thin K-Monel sheet are cut and heat-treated according to the maker's instructions, to harden the alloy and increase its elasticity. These are then cemented to the two faces of the ring with "Araldite" polyester resin. A small radial hole in the ring allows gas

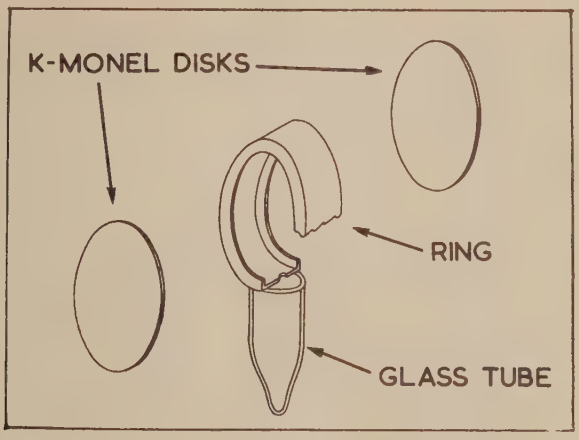


Figure 1. Construction of metal float.

to escape during the cementing process. A short length of glass tube is then cemented to the ring, over the hole. This is drawn down to a narrow neck, and sealed temporarily with wax.

The float is now adjusted for density by immersing it in a beaker of suitable sea water and resting small pieces of thin copper wire on top until the float almost sinks, rising only slowly when pushed below the surface. The glass tube is opened and seven-eights of the wire pushed into the interior. The glass tube is then sealed with a blowpipe, the final adjustments of buoyancy being made by adding or removing small amounts of glass.

The sensitivity of the float to pressure can be modified in several ways, but the most convenient dimension to change is the internal diameter of the ring; this, of course, modifies the effective diameter of the Monel springs. The dimensions of the standard floats are shown in Table 1.

The sensitivity depends on the 4th power of the internal diameter, other things being equal.

Table 1

	Inches	Millimetres
External diameter of ring	0·790	20·0
Lenght of ring	0·276	7·0
Diameter of Monel disk	0·750	19·0*
Thickness of Monel disk	0·008	0·2
Mean thickness of channel section in ring	0·008	0·2
Internal diameter of ring for range of		
salinity of 3‰	0·530	13·5
4‰	0·565	14·3
6‰	0·610	15·5
8‰	0·650	16·5
10‰	0·690	1·75

* If the internal diameter of the ring is above 16 mm. it is advisable to increase the diameter of the disk to 20 mm. to ensure adequate adhesive area.

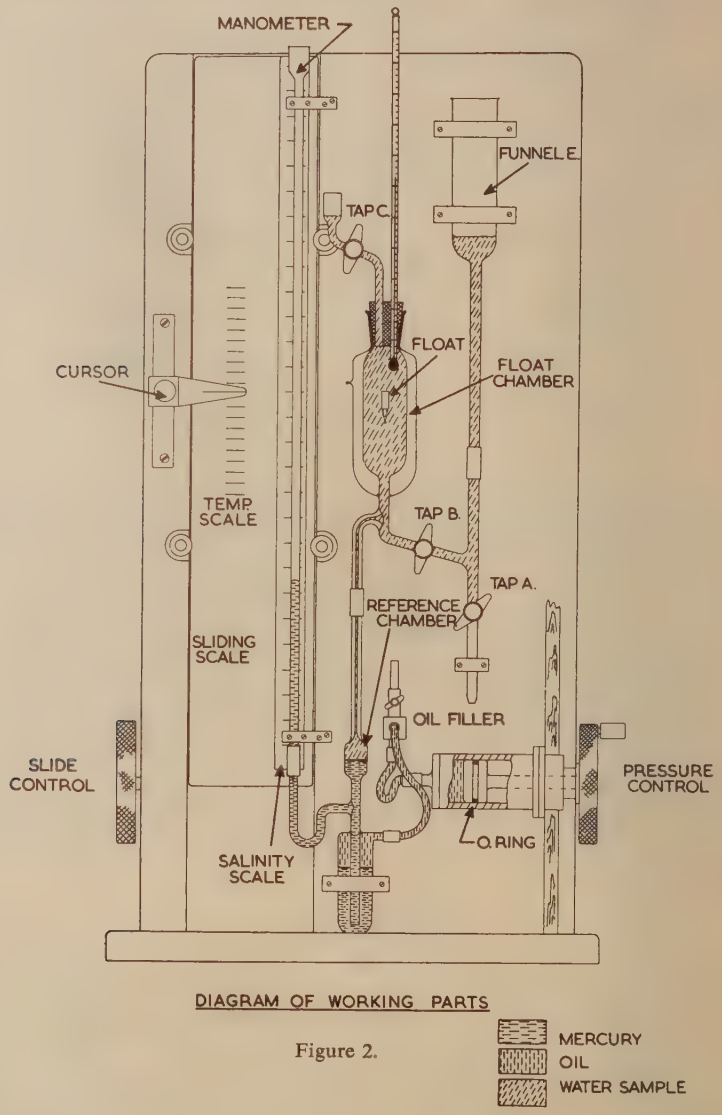


Figure 2.

The general layout of the apparatus can be seen in Figure 2. The float is contained in a pyrex glass chamber surrounded by a vacuum jacket to minimize temperature effects. The sample is run in through the funnel E and is confined in the chamber by the spring-loaded taps B and C. Mounted on the back of the instrument panel is a cylinder filled with oil, shown in

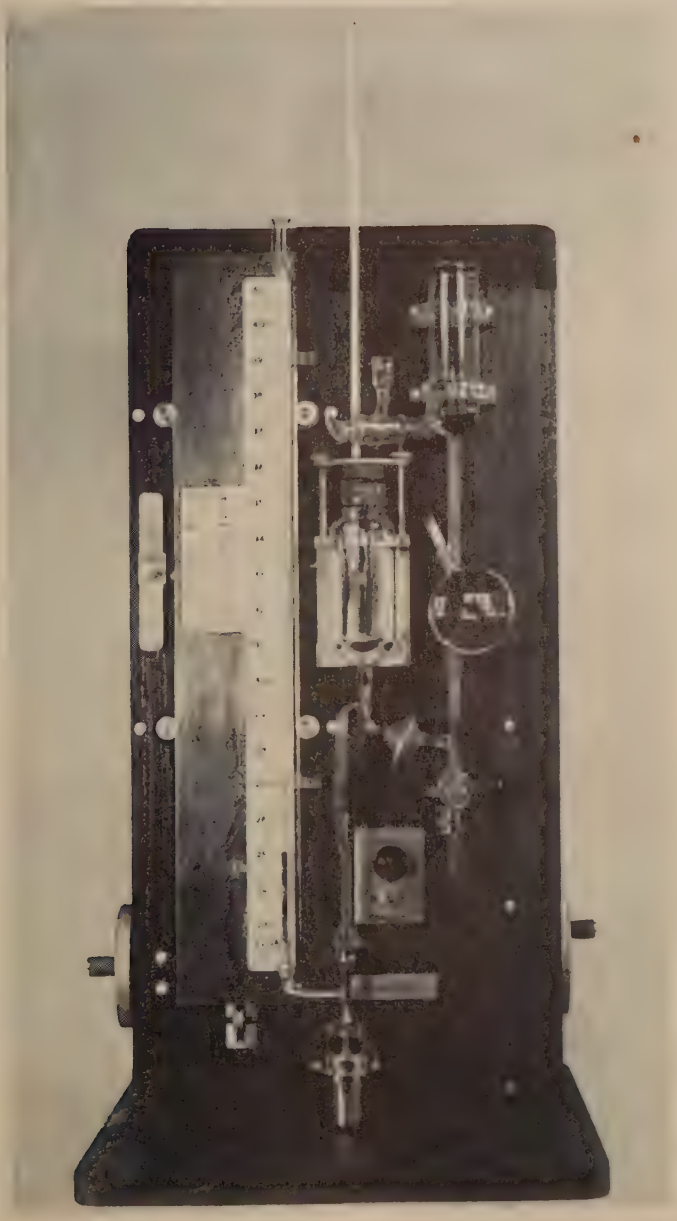


Figure 3. Front view of apparatus in working order.

Figure 2 on the lower right. A piston sealed by an O-ring is forced into the cylinder by rotating the pressure-control wheel. The oil from the cylinder displaces mercury from the lower chamber of the manometer, forcing the mercury up the manometer tube. The "head" of mercury between the manometer and an engraved line in a small reference chamber exerts a pressure which is communicated to the float chamber by a capillary tube. By suitable use of the pressure control the float is first compressed until it sinks and then adjusted until it is neutrally buoyant near a reference mark. The float is illuminated by a low-voltage lamp, and a lens is fitted which can be used to magnify the movements if desired.

If we ignore certain minor effects which are considered below, the pressure on the manometer is now a measure of the density of the water. To convert this to a reading of salinity the effect of temperature must be allowed for. The salinity scale is mounted behind the manometer on a sliding panel, controlled by a second hand-wheel. Alongside the salinity scale is a second scale calibrated in temperature, and reading against an adjustable cursor on the main panel. The temperature of the water sample, with the float balanced, is read on the thermometer, and the sliding scale adjusted until the cursor indicates the same temperature. The manometer now shows the true salinity of the sample.

The barometric pressure and any accumulation of grease on the float affect the zero of the instrument. To allow for this it is calibrated before each series of measurements against a standard sea water, and the temperature cursor is adjusted until the reading of salinity on the scale corresponds to that of the standard. The preparation of artificial standard water is discussed below.

Computing the scales

It is necessary to compute and draw a set of scales for each float, as it is impracticable to make the floats exactly interchangeable. The float is immersed in a pressure-tight container filled with sea water of known salinity, and the whole mounted in a thermostat at a standard temperature. The pressure necessary to make the float neutrally buoyant is determined, and the process repeated for several different water samples of known salinity spaced over the range to be covered by the instrument. These calibrations can be made in the instrument, with the sliding scale temporarily replaced by a fixed linear one, but in this case the samples are unlikely to be all identical in temperature, and the variations must be allowed for by successive approximations in the calculations. The salinity scale is made by suitable interpolations between the fixed points determined by this procedure.

If a float were a perfect spring, this scale would be a linear one, as the relationship between salinity and density of sea water is a straight line. In practice the scale is not linear, although with a well constructed float it is a fairly close approximation. Floats designed for small ranges of salinity are more accurate in this respect than wide-range ones, as the total volume change is correspondingly less.

The temperature scale is now computed from the salinity scale. Let us for the moment assume that the latter is linear, and that the vertical interval corresponding to one part per mille of salinity is 100 mm. The vertical interval corresponding to a change of temperature can now be computed from the various σ^t tables, and such figures are shown in the first column of Table 2. There are two further effects which modify these values. The float itself expands, and the gas inside also expands with increasing temperature. Both these effects reduce the main correction. The coefficient of expansion per degree C. of both the Monel and the stainless steel is 13×10^{-6}, and the mean density of the float changes in proportion. The density change corresponding to $1^0/_{00}$ in salinity is about 760×10^{-6}. These figures reduce the values in column 1 by 1·7 mm. in each degree, as shown in column 2. The expansion of the included gas is more difficult to compute, as the conditions at the moment of sealing are not precisely known. If these are taken as 30°C. and 760 mm. the effect of air expansion is to reduce the main correction by 2·5 mm. per degree.

The corrections for a typical float are summarized in Table 2.

Table 2

Temperature correction scale in mm. for a float with a vertical interval of 100 mm. per $1^0/_{00}$ S

Temperature range °C.	Main correction due to expansion of water	less expansion of float	less included gas effect
16–17	31·8	30·1	27·6
17–18	33·1	31·4	28·9
18–19	34·5	32·8	30·3
19–20	35·9	34·2	31·7
20–21	37·3	35·6	33·1
21–22	38·6	36·9	34·4
22–23	40·0	37·3	35·8

Since a float is never perfect, the temperature scale plotted from the last column in Table 2 can only be accurate at one pressure. It is possible to compute a series of scales which will each be correct at one point. When, however, it is necessary to compare a sample with a standard widely different both in temperature and salinity, then errors are introduced which cannot readily be overcome. It is usually found convenient in practice to keep samples and standard in the same room for an hour or two before analysis, when the variations in temperature will be so small as to make the errors insignificant. A scale plotted from the mean salinity interval will then be sufficiently accurate.

Standardizing the meter

The international standard for salinity is Copenhagen "Normal Water". This, however, is guaranteed only as a chlorinity standard for titration with silver nitrate. It is not necessarily valid to assume that the density of

this "Normal Water" will correspond with that of natural sea water of the same chlorinity, especially after the water has been stored for long periods. Such storage does not appear to affect the chlorinity, but we have some evidence that the density may change. Accordingly, it is recommended that for the most accurate results a substandard be prepared from natural sea water standardized either by titration against "Normal Water" or by direct determination of density in a pyknometer.

In laboratories without proper facilities for standardizing natural sea water it is possible to prepare an artificial density standard, and instructions are given below for doing this. It is emphasized that this artificial standard is not in any way intended to replace "Normal Water" as the ultimate standard of salinity, and should salinities based on such secondary standards be published, it must be made clear that they are not referred directly to the international standard.

Directions for preparing artificial standard water

Dry about 40 g. of A. R. sodium chloride at 200°C. for 30 minutes and cool in a desiccator. Weigh accurately about 38 g. of this dry salt, exposing it to the air as little as possible, and dissolve in distilled water. Make up to 1 litre in a soda-glass graduated flask, and measure the temperature of the solution.

Table 3 gives the equivalent salinity of a solution of exactly 38 g. of salt when made according to these directions and at various temperatures. This table is computed on the assumptions that the salt solution has the same coefficient of expansion as sea water of similar density, and that the coefficient of cubical expansion of the glass in the flask is 0·0000255 per degree C. It is not valid for a flask of borosilicate glass.

Table 3

Temperature of solution after adjustment, °C.	Equivalent salinity with 38 g. salt, ‰
16·4	34·97
17·4	34·96
18·5	34·95
19·9	34·94
21·1	34·93
22·3	34·92
23·5	34·91
24·7	34·90

If the weight of salt taken is not exactly 38 g., the equivalent salinity can be computed by simple proportion from Table 3.

There are only two considerable errors likely to arise in preparing this water; the first comes from water in the sodium chloride and the second from inaccurate calibration of the volumetric flask. Sodium chloride cannot be freed completely of water without fusing it, and shortly above the fusion point it decomposes. The figures in the table are computed from experimentally determined densities obtained by following the instructions given

above. The errors produced by other batches of salt should not be significant if the same procedure is followed. Errors in the flask are likely to be more serious. The tolerance on a grade A 1-litre flask is $\pm 0{\cdot}3$ ml. and on a grade B flask is $\pm 0{\cdot}6$ ml. These tolerances introduce uncertainties of about $0{\cdot}01\,^0/_{00}$ and $0{\cdot}02\,^0/_{00}$ respectively, and flasks are often outside these tolerances, particularly if they have been mishandled by heating. If high accuracy is needed, the flask should be recalibrated or a flask of certified volume used.

Results obtained with the instrument

Results obtained by various workers using the instrument show that a normal precision of $\pm 0{\cdot}02\,^0/_{00}$ is obtained without difficulty with a float covering a salinity range of $33\text{–}37\,^0/_{00}$. With floats of wider range precision is reduced somewhat. The time taken to make each observation varies with the operator, but a typical figure is $3\frac{1}{2}$–4 mins. The prototype instrument has been in regular use for over a year without any serious difficulties arising, and over 300 samples have been measured. The most troublesome source of errors has been a tendency for air to be carried into the float chamber during filling, causing small air bubbles to stick to the float. These can be largely prevented by careful filling and by keeping the glassware clean, and a small baffle can be incorporated in the float chamber to deflect the bubbles away from the float. In work with very contaminated estuarine samples, it has been found beneficial to add a trace of detergent to the samples before measuring.

Conclusion

The compressible-float salinity meter previously described has been modified to make it more reliable, easier to use, and simpler to make. The accuracy of the earlier meter is maintained, and some improvement made in speed of operation. Further details of the apparatus, and full workshop drawings, can be obtained from the National Institute of Oceanography, Wormley, Godalming, Surrey, by anyone interested in building a similar instrument. It is hoped that the meter will be particularly useful to laboratories where relatively few determinations of salinity are made, as it is always ready for use with practically no maintenance or operating expenses. For the routine determination of large numbers of samples the electrical conductivity meter recently built by Bradshaw and Schleicher (2) is likely to prove superior.

The author wishes to express his thanks to the many members of the staff of the Institute of Oceanography who have helped in the development and construction of this instrument, in particular to Mr. D. I. Gaunt who was responsible for the mechanical design; also to Mr. A. C. Duxbury and Dr. R. G. Paquette of the University of Washington, USA, who pointed out the importance of the secondary effects in the computation of the temperature scales, which were completely overlooked in the earlier report.

Synopsis

Improvements have been made to the float-type salinity meter. The all-glass float has been replaced by one incorporating metal springs, and the mechanical design has been modified to increase speed of operation. The precision of the apparatus is still approximately equal to that of the standard chemical method. Details and dimensions are given for the construction of floats to cover any desired range of salinity, and for computing the necessary scales. An artificial density standard suitable for approximate work is described.

References

1. Cox, R. A. J. du Conseil, **20** (1): 9–17. 1954.
2. BRADSHAW, A. L., and SCHLEICHER, K. E. Woods Hole internal report No. 56–20, March 1956. (Unpublished manuscript.)

The Separation of Potential Males and Females in Stage-V Copepodites of *Calanus helgolandicus*

By

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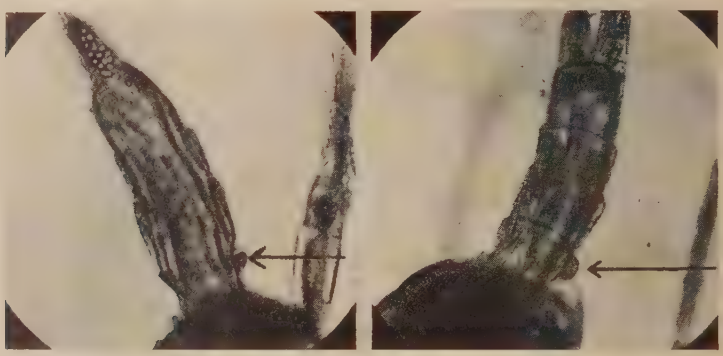
In a number of copepods it is possible to identify the sexes before they reach the adult stage. Working on the Copepoda of the Indian seas, Seymour Sewell (1929) was able to separate males from females in the fifth and even fourth stage copepodites by examination of the fifth pair of thoracic legs. Similarly Krefft (1910) used this character to separate the sexes in the copepodite stages of a number of commoner North Sea copepods; he also used the shape of the urosome as a distinguishing character in some cases. This type of separation has not been achieved for *Calanus helgolandicus*, a rather primitive form, in which the fifth pair of thoracic legs shows no sexual differentiation in copepodite stage five. However, a method has been tentatively suggested by one of us for separating the sexes of *Calanus finmarchicus* G. in the stage-V copepodite by examination of the first segment of the urosome (Woodhead, in Cushing, 1955). At the same time, an attempt was made to achieve a similar separation for *Calanus helgolandicus* in the North Sea, but with this feature, it was reported that in a sample of 44 stage-V *Calanus helgolandicus*, no potential males were found.

The opportunity recently arose to examine some samples of *Calanus* from the English Channel, where the predominating form has been reported to be *Calanus helgolandicus* (Russell, 1951). The results of this study are presented here.

Distinction by Urosome

All *Calanus* examined from the Channel samples were found to be *Calanus helgolandicus* of the type described by Rees (1949). The material used consisted of fifth-stage copepodites which had been caught in a vertically hauled Hensen net and preserved in 5% neutral formalin as soon as possible after collection. The whole sample was taken from one station near the centre of a dense patch of stage-V copepodites in the western part of the English Channel in June 1950.



a b

Figure 1. Side view of the urosome in potential male (a) and female (b) stage-V copepodites of *Calanus helgolandicus;* the two types are distinguished by the degree of curvature of the ventral surface of the first (proximal) urosome segment (indicated by arrows).

Examination of the first (proximal) segment of the urosome of these copepodites showed that two distinct types could be distinguished. In both of these types the ventral surface of the first urosome segment was markedly curved posteriorly, but whereas in one group the curve consisted simply of a rounded lip overlapping the second segment, in the second group the curve was more pronounced, extending further forward and tending to bulge the segment further ventrally. Photographs of typical examples of the two types of urosome are shown in Figure 1. It was thought that these groups might represent potential male and female populations respectively.

Biometrical separation

Studying the biometry of *Calanus finmarchicus* in the Clyde, Barnes and Barnes (1953) found that in stage-V copepodites, many of the measurements fell quite clearly into two size-groups, suggesting the presence of two populations within the sample. In particular, they found that in one group the head was longer, and the metasome narrower, than in the other group. They suggested that these two groups represented potential male and female populations, relating the group with the long heads and narrow bodies to adult males, and the second group to females. However, Barnes and Barnes emphasize the point that these differences refer to populations, not individuals.

When the present sample of *Calanus helgolandicus* was similarly measured under the microscope, it also revealed two size-populations in stage-V, one having a longer head, although being only slightly thinner in the body, than the other (Table 1).

A more marked separation of the two groups, potential males and females, could be achieved by dividing the head length by the width of the first free segment of the metasome for each copepodite; another ratio was derived by dividing the metasome length by the head length. The use of ratios eliminated

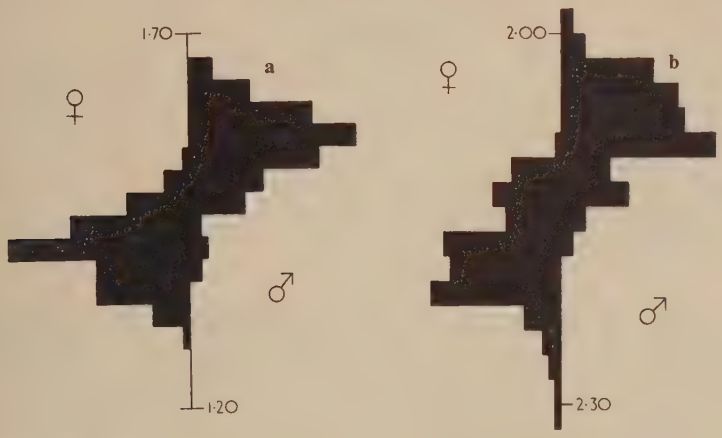


Figure 2. Frequency distribution of the ratios (a) of head length to width of first free metasomal segment, and (b) of metasome length to head length, for stage-V copepodites of *Calanus helgolandicus* classified as male and female on the urosome feature.

the effect of size from the analysis. These methods of separation were used to confirm the method of dividing stage-V copepodites into two groups on the urosome feature. To do this, the copepodites were first put into potential male and female groups by examination of the urosome, and then the head length, metasome length, width of the first free metasomal segment, and total length were measured. The ratios were derived, and it was found that a close approach to a normal distribution was achieved for each population selected on the urosome feature (Figure 2, a and b).

The very close agreement between the urosome and biometrical methods for separating the males from females, taken with the fact that both select on features which approximate to the adult male and female conditions, suggests strongly that the two populations described within stage-V copepodites of *Calanus helgolandicus* are indeed composed of potential males and females. The potential males at this station formed 55% of the copepodites.

Calanus helgolandicus in the North Sea

In both male and female *Calanus helgolandicus* in stage V the ventral surface of the urosome was more curved than in the corresponding sex in *Calanus finmarchicus*, and by *finmarchicus* standards, all would probably be classified as potential females. In view of this and of the percentage of males found in the English Channel sample, it was decided to re-examine some of the *Calanus helgolandicus* samples from North Sea stations reported to contain only potential females (Woodhead, in Cushing, 1955). In a sample of 48 stage-V copepodites taken from one of these stations ("Sir Lancelot", Cr. X, 1949, St. 15), 21 were found to be of the potential male type. It must therefore be concluded that the method previously reported was not sufficiently sensitive to distinguish between the sexes of stage-V *Calanus helgolandicus* in the small North Sea sample examined.

Table 1

		Head length	Metasome length	Total length	Width 1st free metasomal segment
100 Male	Mean (E.P.U.)	3·28	6·79	8·64	2·13
	Standard deviation	±0·07	±0·15	±0·18	±0·09
100 Female	Mean (E.P.U.)	3·07	6·67	8·51	2·18
	Standard deviation	±0·08	±0.19	±0·24	±0·09
Significance of difference between male and female (t)		19·3	4·9	4·4	3·8

1 E.P.U. 0·33 mm.

In order to discover whether any geographical or seasonal variation occurred in the biometric ratios, a number of North Sea copepodites, collected in June 1949 and April 1954, were measured and compared with the English Channel sample. The 1949 copepodites were about the same size as the Channel copepodites, and the 1954 North Sea copepodites were decidedly larger, but in neither case did there appear to be any difference in the ratios derived from the measurements.

Summary

A method for separating the sexes in the stage-V copepodite of *Calanus helgolandicus*, by examination of the proximal segment of the urosome, is suggested. In the potential females, the ventral surface of the segment is more markedly curved, and the curve extends further forward than in the potential males.

Biometrical separation also revealed two groups within the stage-V copepodites, and the very close agreement obtained between this method and the urosome method of separation suggested strongly that the two groups described were indeed potential males and females.

No geographical or seasonal variation in the biometrical ratios was found in the North Sea samples examined.

References

Barnes, H., and Barnes, M., 1953. "Biometry of the copepod *Calanus finmarchicus* (Gunn.) in Stages V and VI." J. Mar. Biol. Assoc. U.K., **32**: 305–13.

Cushing, D. H., 1955. "Production and a Pelagic Fishery". M. A. F. F., Fish. Invest., Ser. 2, **18** (7).

Krefft, F., 1910. "Über das Plankton in Ost- und Nordsee und den Verbindungsgebieten, mit besonderer Berücksichtigung der Copepoden". Wiss. Meeresunters., N. F., Abt. Kiel, **11**: 29–107.

Rees, C. B., 1949. "Continous plankton records. The distribution of *Calanus finmarchicus* (Gunn.) and its two forms in the North Sea, 1938–39." Hull Bull. Mar. Ecol., **2**: 215–75.

Russell, F. S., 1951. "A re-examination of *Calanus* collected off Plymouth". J. Mar. Biol. Assoc. U. K., **30**: 313–14.

Sewell, R. B. Seymour, 1929. "The Copepoda of Indian Seas. *Calanoida*". Mem. Indian Mus., **10**: 1–221.

The Effect of Gill-Net Selection on the Estimation of Weight-Length Relationships

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I. Introduction

Gill-nets are widely used, especially in commercial fisheries; they are also the most satisfactory gear for the experimental fishing of waters difficult of access, as they require few handlers and only a small boat (or inflatable dinghy). It is obvious, however, that gill-nets select for size (small fish swim right through, big ones cannot enter the meshes) and it is known that they are selective for length-condition relationship (FARRAN, 1936) and length-girth relationship (MARGETTS, 1954). The weight-length relationship has sometimes been calculated from measurements of weight and length obtained from gill-netted samples, despite the possibility of the gill-net taking the fatter of the short fish and the thinner of the long fish. In this paper the selective effect of gill-nets on the weight-length relationship is discussed, together with the question of whether gill-netted samples are reliable for the calculation of this relationship.

This problem arose when selection by gill-nets became apparent during investigations into the biology of char (*Salvelinus alpinus willughbii* (GÜNTHER)) and perch (*Perca fluviatilis* LINN.) by Dr. W. E. FROST and Mr. E. D. LE CREN respectively. Samples of both these species were caught in Windermere by various fishing methods, including gill-nets. Analysis of the weight-length relationships showed that in some, but not all, cases, the results from the gill-netted fish were inconsistent with the results from other sources.

For example, immature dwarf char taken in a $\frac{1}{2}''$ bar gill-net did not differ in weight-length relationship from those taken by seine, whereas those taken by a $\frac{3}{4}''$ bar gill-net differed significantly. By adding the data from the two gill-nets a result which did not differ significantly from the seine-caught sample was again obtained. Also spawning male char caught in a $1\frac{1}{4}''$ bar

gill-net in the autumn differed significantly from spawning males taken by seine at the same time of year. Again, female mature perch caught in traps did not differ significantly from comparable fish taken in a $\frac{3}{4}''$ bar gill-net, whereas the males showed a significant difference.

In view of these discrepancies it was decided to investigate the manner in which the gill-net selects for weight-length relationship and to find out whether a reliable estimate of the population weight-length regression coefficient could be obtained from measurements of fish caught in gill-nets.

II. Materials and Methods

The gill-nets used were single walls of netting, weighted to sink. They were usually set in deep water and were examined at least every twenty-four hours. The herring gill-net was made of cotton twine, 36/9 ply, with mesh-size $1\frac{1}{4}''$ (3·17 cm.) bar. All the other gill-nets used were of flax twine, with mesh-sizes $\frac{1}{2}''$ (1·27 cm.) bar, $\frac{3}{4}''$ (1·90 cm.) bar, 1″ (2·54 cm.) bar, $1\frac{1}{4}''$ (3·17 cm.) bar, $1\frac{3}{4}''$ (4·44 cm.) bar, all of 60/3 ply, and 2″ (5·08 cm.) bar of 35/3 ply. Mesh-sizes were checked by inserting and measuring graduated rubber bungs. They were mostly accurate to within 2 mm.; the maximum error found was 4 mm.

The standard seine was 50 yd. (45·7 m.) long, and 4 to 5 yd. (3·7 to 4·6 m.) deep, the mesh being graded from 1″ (2·54 cm.) bar on the wings to $\frac{3}{8}''$ (0·95 cm.) bar at the bag. It was always worked from the shore.

The traps in which perch were caught have been described by WORTHINGTON (1950). The method of angling used for perch was the paternoster with minnow or worm for bait. The method of angling for char by plumb-line has been described by WATSON (1925, Appendix 1).

The length of char was measured from the tip of the snout, with the mouth closed, to the fork of the caudal fin, and perch from the tip of the pre-maxilla to the tip of the longest caudal fin-ray stretched out posteriorly. The maximum girth and the head girth at the pre-opercular bone were measured by encircling the fish with a piece of string at the required point and measuring the string on a ruler. Both char and perch were weighed on a "Butchart" swinging arm balance, usually to the nearest gramme. Lengths were grouped in half centimetres, and the logarithms of the weights were grouped with intervals of 0·05.

The weight-length relationship was calculated from the formula

$$W = AL^b \qquad \text{where } W = \text{weight}, \; L = \text{length}, \; A = \text{a constant}, \; b = \text{an exponent, ideally equal to 3.}$$

Expressed in logarithms, this is a straight line.

$$\text{Log. } W = \text{log. } A + \text{b log. } L$$

$$\text{or} \quad y = a + b_{yx}x \qquad \text{where } y = \text{log. weight}, \; x = \text{log. length}, \; a = \text{a constant}, \; b_{yx} = \text{the regression coefficient}$$

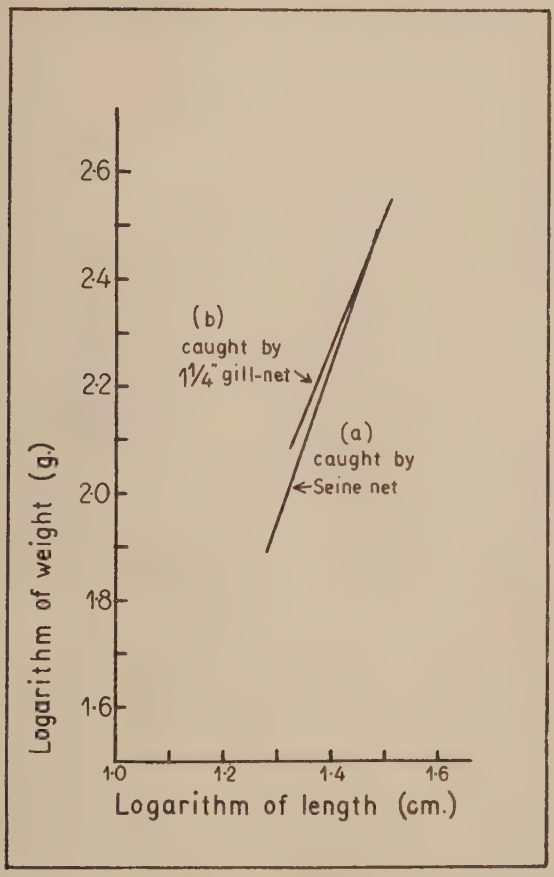

Figure 1. Regression lines of the logarithm of weight on the logarithm of length for male mature char caught in the autumn by (a) seine and (b) 1¼" bar gill-net. The slopes of the lines differ significantly.

The quantity b_{yx} calculated from the sample is an estimate of the population regression coefficient β_{yx}.

The regression equations were calculated by the usual method of least squares. The regression coefficient b_{yx} gives the slope of the regression line of the logarithm of weight on the logarithm of length. This line is used to estimate weight from length. Length is here the independent variable and weight the dependent variable. The standard errors of the regression coefficients were calculated, and the differences between regression coefficients (i.e., slopes of regression lines) tested by the F-test (Snedecor, 1946); Figure 1 shows two such regression lines the slopes of which differ significantly.

Table 1

Comparison of regression coefficients

		Method of catching	Number of fish	Length range cm.	Regression coefficient b_{yx} (slope)	Standard error of regression coefficient	Significance of difference between regression coefficients
(1 a)	Imm. dwarf char	Seine	62	5–21	**3·18**	*(0·06)*	not significant
	– – –	½″ + ¾″ bar gill-nets	82	11–21	**3·17**	*(0·06)*	
(1 b)	– –	½″ bar gill-net	19*	10–21	**3·14**	*(0·13)*	not significant (from **3·18**)
	– –	¾″ bar gill-net	59*	12–20	**2·72**	*(0·15)*	significant (– –)
(1 c)	– –	Under 14 cm. ½″ + ¾″ bar gill-nets	20	10–13	**2·59**	*(0·34)*	not significant (– –)
	– – –	Over 14 cm. ½″ + ¾″ gill-nets	62	15–21	**2·64**	*(0·17)*	significant (– –)
(2)	Imm. normal char	Angled	34	14–26	**3·22**	*(0·19)*	not significant
	–	1″ + 1¼″ + 1¾″ bar gill-nets	38	18–27	**3·30**	*(0·16)*	
(3)	Male mature char	Angled	38	17–32	**2·75**	*(0·20)*	significant
	–	1¼″ bar herring gill-net	45	26–31	**1·87**	*(0·24)*	
(4)	Female mature char	Angled	20	23–31	**2·60**	*(0·24)*	not significant
	– – –	1¼″ bar herring gill-net	42	24–31	**1·97**	*(0·25)*	
(5)	Male mature char	Seine autumn	24	19–30	**2·92**	*(0·17)*	significant
	– – –	1¼″ bar gill-net	31	21–32	**2·49**	*(0·12)*	
(6)	Male mature char	Seine spring	78	21–38	**2·73**	*(0·09)*	significant
	– – –	1″ + 1¼″ + 1¾″ + 2″ bar gill-nets	33	19–37	**3·02**	*(0·08)*	
(7)	Female mature char	Seine spring	24	22–34	**2·67**	*(0·21)*	not significant
	– –	1″ + 1¼″ + 1¾″ + 2″ bar gill-nets	31	24–35	**3·07**	*(0·22)*	
(8 a)	Female mature perch	Trapped	394	12–28	**3·43**	*(0·04)*	not significant
	– –	¾″ bar gill-net	110	14–24	**3·26**	*(0·07)*	
(8 b)	– –	Under 16 cm. ¾″ bar gill-net	87	14–16	**2·79**	*(0·14)*	very significant (from **3·43**)
	– – –	Over 16 cm. ¾″ bar gill-net	23	17–24	**3·30**	*(0·21)*	not significant (– –)
(9)	Male mature perch	Trapped	161	10–19	**3·30**	*(0·04)*	significant
	– – –	¾″ bar gill-net	38	14–18	**2·82**	*(0·17)*	

* For four fish the size of the net in which they were caught was not recorded.

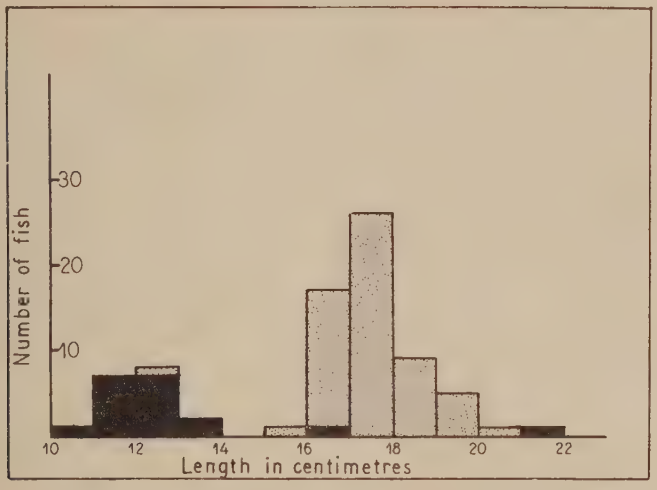

Figure 2. Length-frequency distribution of immature dwarf char caught in $\frac{1}{2}''$ bar (black columns) and $\frac{3}{4}''$ bar gill-nets (stippled columns).

III. Results of Sampling

Regression coefficients and their standard errors were calculated by the above method for nine pairs of samples and tested for the significance of the difference between the members of each pair. Each consisted of a gill-netted sample and one taken by some other fishing method. The pairs were similar as regards sex, gonad condition, and season of capture. It was assumed that fish taken by the other fishing methods, i. e., by seines, traps, and angling, were not selected in respect of weight-length relationship. Table 1 gives details of the samples. It can be seen that four of the differences between the pairs of regression coefficients are significant, and five are not significant. These results will now be considered more fully.

(1) Immature dwarf char were caught in two sizes of gill-net and also by seine. A comparison of the regression slope of the combined gill-net data with that of the seine showed almost identical results, 3·17 for the gill-nets and 3·18 for the seine. Figure 2 shows the length-frequency distribution of the catch in the two gill-nets. It can be seen that they are in two distinct length groups (under and over 14 cm.) and that the $\frac{1}{2}''$ bar gill-net has caught two fish in the larger group (possibly by the jaw being entangled in the net), while the $\frac{3}{4}''$ bar gill-net caught one in the smaller group.

When the two sizes of gill-net were considered separately the slopes were:– $\frac{1}{2}''$ bar gill-net, 3·14; $\frac{3}{4}''$ bar gill-net, 2·72 (see Table 1, 1b). The two length groups separately had slopes of 2·59 for the "under 14 cm." group and 2·64 for the "over 14 cm." group (see Table 1, 1 c). The presence of fish of "outlying" lengths in the gill-nets has changed the regression slope from the 2·59 for "under 14 cm." to 3·14 for the $\frac{1}{2}''$ bar gill-net, and similarly from 2·64 for the "over 14 cm." to 2·72 for the $\frac{3}{4}''$ bar gill-net,

in each case giving a closer approximation to the regression slope of unselected fish caught by seine.

(2) Immature char of normal growth, ranging from 18 to 27 cm., were caught in a series of gill-nets of size 1″ bar, 1¼″ bar, and 1¾″ bar. They gave a regression slope of 3·30. This did not differ significantly from the regression slope of 3·22 for unselected immature fish of similar length range caught by anglers.

(3) and (4) The next examples show the effect on the regression slope of using data from a single gill-net which had caught no fish of extreme size. The information was derived from mature char caught in a 1¼″ bar herring gill-net. The regression slopes for the gill-netted fish were 1·87 (male) and 1·97 (female). A comparable sample of angled fish had regression slopes of 2·75 (male) and 2·60 (female). The slopes for the males differed significantly, and although the difference between those for the females proved to be not significant, again the gill-netted fish gave a less steep slope than the angled.

(5) A similar result was obtained by comparing spawning male char caught by a single-size gill-net with like fish taken by seine. Fish from a 1¼″ bar gill-net set at Low Wray in the late autumn gave a slope of 2·49. This differed significantly from the slope of 2·92 for spawning males caught by seine at Red Nab in November.

(6) and (7) In all the previous examples the regression slopes worked out from gill-netted samples have been less than those of the unselected samples. However, for spawning char from a series of four sizes of gill-nets the slopes for both males and females were greater than those of comparable samples taken by seines. It seemed likely therefore that there was another type of selection occurring which tended to increase the slope. Further investigation revealed that from the total fish caught in the gill-nets, samples had been purposely selected for weight and colour, which in this species are closely correlated, the biggest and heaviest fish being the most brightly coloured, and *vice versa*. In general the fish of extreme weight and colour were brought back to the laboratory for detailed study, and it was mainly from these that weight and length measurements were available. It is apparent that such selection of short and thin, and long and fat fish would increase the regression slope. The fish from the seines were taken at random for weighing and measuring, and therefore these samples were not biased in the same manner. In the case of the males, which tend to be bigger and brighter than the females, the regression coefficient of the gill-netted fish was significantly greater than that of the fish caught by seines. The slopes for the two samples of females did not differ significantly.

(8) The regression slope for 110 female mature perch caught in a ¾″ bar gill-net in early spring was 3·26. This did not differ significantly from the slope of 3·43 for 394 female mature perch caught in traps in the spring. The netted fish had a length range of 13·5–23·5 cm. and the trapped 12·0–27·5 cm. Now the upper length limit of catching by the body by a ¾″ bar gill-net is known to be about 16 cm. Of the 110 netted fish 23 were "outliers" above this limit, and would therefore be expected not to be selected for length-weight relationship. The fish were therefore divided into two groups, over 16 cm., and 16 cm. and under, and the regression slopes calculated for each

group separately (see Table 1, 8b). The slope for the larger fish did not differ significantly from that for the trapped fish, whereas the slope for the smaller, which were meshed by the body, was very significantly less. The presence of the "outliers" gave the whole sample a slope which did not differ significantly from that of the unselected trapped fish.

(9) The 38 mature males caught in a $\frac{3}{4}''$ bar gill-net at the same time had only 3 "outliers" over 16 cm. The regression slope for this sample differed significantly from that for the trapped males.

These results can be summarized as follows: —

1. Three out of the four significant differences between the slopes of the pairs of samples occurred when only one size of gill-net was used. In each of these cases the gill-net coefficient was the smaller.

2. The other significant difference came from a biased sample.

3. Of the five non-significant results three came from samples obtained with more than one size of gill-net. In the other two cases the gill-net had caught fish of a relatively wide length range.

4. The presence of a few "outliers" has been shown to have a considerable effect on the slope of the regression line.

IV. Discussion

In the theoretical discussion it is assumed that all fish were caught in a gill-net or nets of one mesh-size only. Methods of catching are first considered and then possible methods of selection.

The gill-net is usually set for at least twenty-four hours, and obviously the fish must be firmly held during the waiting period and during the pulling up of the net, when any insecure fish will fall out and be lost. The fish may be caught by the jaw, or other bony parts of the head, becoming entangled in the net without its body entering the meshes. In this case the range of possible fish size is great, and for any particular length the weight will not be selected, since the shape and fatness of the fish will play no part in its capture. It is possible that small fish caught in this way may escape more easily, but there can be no selection of fish of restricted weight-length relationship. Fish caught thus will be ignored in the theoretical discussion.

The majority of fish are not caught in the manner just described, but are held by the meshes encircling the body. A perch, for example, may be held anywhere between the points A and B shown in Figure 3. The circumference at A determines the maximum size of fish held; if it is greater than that of the meshes, the fish will not be able to enter far enough to be held fast. The position of the critical point A will vary for different species. The minimum size of fish held depends on the circumference at B, i.e., the maximum circumference. If this is less than that of the meshes, then the fish can swim right through. It is evident that only fish of a limited range of size will be caught by the body between A and B, and that some selection for size is certain to occur. Only fish thus meshed by the body are considered in the theoretical discussion. (It should be noted that it is not in fact practicable to sort fish into the two different categories on removing them from the net.)

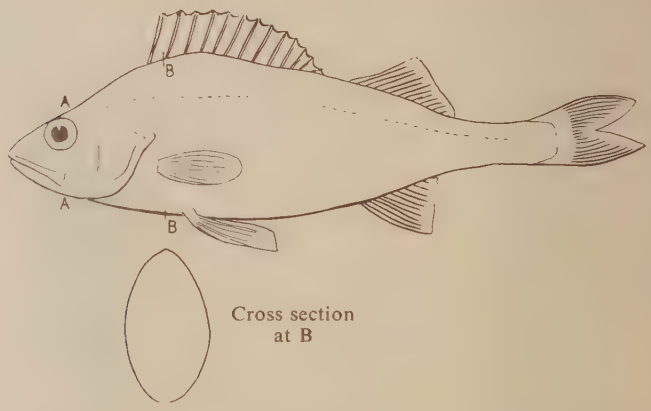

Figure 3. Outline of a female mature perch caught by 1¼″ bar gill-net. Length 23·8 cm. Weight 151 g. Girth 13·8 cm.

The assumptions that all fish are meshed by the body and that only one mesh-size of gill-net is used can give an estimate of the maximum expected effect of gill-net selection. Departure from these assumptions, either through the use of two or more sizes of mesh or by catching "outliers", gives the sample a greater length range and results in a more accurate estimate of the population weight-length relationship.

Three possible methods of selection are now considered theoretically.

1. Truncation by length. The rejection of all fish above an upper length limit and below a lower length limit.
2. Truncation by weight.
3. Truncation by girth.

These are shown in Figure 4, and a calculated artificial example is given of truncation by length and truncation by weight.

The weight-length regression line in Figure 4a has a slope (b_{yx}) of 3. For every unit increase in x (log. length), y (log. weight) increases 3 units. The points (not shown) for individual fish would be scattered about the line, those for fish fatter than average being above the line, and for fish thinner than average below the line. The broken lines represent the 0·95 confidence limits, within which 95% of the observations may be expected to lie. For the short section of the line under consideration these may be assumed to be parallel to the regression line.

The same line truncated by length is shown in Figure 4b. Truncation by length cuts off a portion of the data with lines parallel to the y-axis. All fish above the upper limit and below the lower limit are rejected. This type of truncation does not alter the slope of the weight-length regression line. The mean weights of each length group are not affected, all remaining on the original regression line.

Truncation by weight is shown in Figure 4c. This cuts off the data with lines parallel to the x-axis. It can be seen that the mean weights of

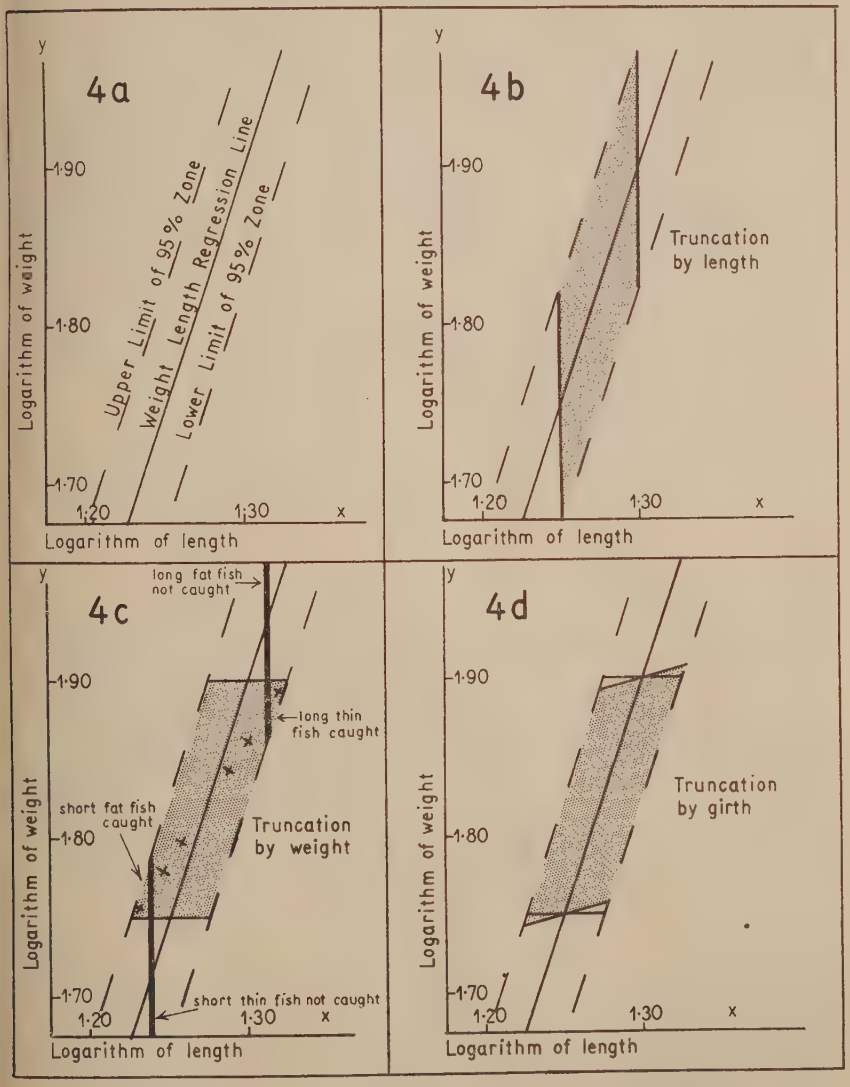

Figure 4. The effects of truncation on weight-length regression.

(a) Weight-length regression line and 0·95 confidence limits.
(b) Truncation by length. Fish of log. length between 1·25 and 1·30 are retained.
(c) Truncation by weight. Fish of log. weight between 1·75 and 1·90 are retained.
(d) Truncation by girth. Truncated zone bounded by lines of constant girth.

fish caught in each length group (marked xxx) no longer lie on the original regression line, and that the line through these means has a less steep slope than the original. In truncation by weight the group with smallest lengths contains only the upper end of its weight distribution — that is, short fat fish. The group of lengths next to the smallest includes more of its weight distribution and so on until the whole weight distribution is covered. In the upper length groups, the reverse happens. Further consideration of increasing length groups shows that the fat fish will be rejected first, and finally only the thinnest fish of the groups with longest length, will be caught. The weight-length regression line calculated from the truncated data therefore has a smaller regression coefficient than the line calculated from the complete data. Therefore if truncation by the gill-net approximates to truncation by weight, the regression coefficient calculated from a gill-netted sample is smaller than that of the population.

Another approach to the question of truncation by weight would be to consider the length-weight regression coefficient b_{xy}, which is used in estimating length from weight, and is not altered by truncation by weight. If ϱ, the length-weight correlation coefficient of the population, is known, then b_{xy} can be used to make an estimate of the population weight-length regression coefficient β_{yx} by the equation

$$\beta_{yx} = \frac{\varrho^2}{b_{xy}}$$

In practice this method is not of much value, as the standard error of the estimate cannot easily be determined, and ϱ is usually not known.

A population of trapped perch was artificially truncated in order to test whether truncation caused a significant difference in the estimate of slopes of regression lines. The artificial limits of truncation were chosen as being approximately the catching limits of the $\frac{3}{4}''$ bar gill-net, so that comparisons could be made with actual catches. For length the limits were 13·5 to 16·0 cm., and for weight 24 to 42 g.; all fish outside these limits were rejected. Separate calculations were made for males and females, for the full sample and for the length-truncated and weight-truncated samples.

The original population consisted of 394 female mature perch and 161 male mature perch. The female population had a length range of 12·0 to 27·5 cm. This was truncated by rejecting all fish less than 13·5 cm. and all more than 16·0 cm.; 131 fish remained for the calculation of the regression coefficient of the sample truncated by length. The weight range of the original female population was 14 to 260 g. This was truncated by rejecting fish of less than 24 g. and more than 42 g.; 99 fish remained in the sample truncated by weight. Similar truncations with the same limits were performed on the 161 male perch. The detailed results of the analysis are shown in Table 2. The regression coefficients of the samples truncated by length did not differ significantly from those of the original populations. The regression coefficients of the samples truncated by weight differed significantly from those of the original populations, and were both smaller, denoting a less steep slope. These results agree with the conclusions reached by consideration of Figures 4b and c.

The observed regression coefficients of mature male perch from several

Table 2

Artificial truncation of perch populations

	Number of fish	Regression coefficient b_{yx}	Standard error of b_{yx}	Significance of difference from population value
Female population.....	394	**3·43**	*(0·04)*	
Truncated by length.....	131	**3·72**	*(0·17)*	Not significant
Truncated by weight.....	99	**2·50**	*(0·19)*	Very significant
Male population.....	161	**3·30**	*(0·04)*	
Truncated by length.....	61	**3·40**	*(0·19)*	Not significant
Truncated by weight.....	48	**2·79**	*(0·17)*	Significant

Table 3

Regression coefficients of artificially truncated and gill-netted samples of mature male perch

	Number of fish	Regression coefficient	Standard error
Sample artificially truncated by weight 24 to 42 g.	48	**2·79**	*(0·17)*
¾″ bar gill-net Jan. Feb.....	38	**2·82**	
– – – March	26	**2·86**	
– – – April.....	22	**2·72**	

settings of a ¾″ bar gill-net were then compared with the coefficient obtained by the artificial truncation by weight described above. The netting results were consistent and were all very close to that of the weight-truncated sample. They are shown in Table 3. Truncation by weight therefore seems to give a good approximation to the selective action of the gill-net.

It is obvious, however, that in practice the gill-net selects, not by length or weight, but by girth. In routine sampling, girth measurements are not normally taken, so direct comparison of girths and meshes was not possible. To obtain a relationship between length, weight, and maximum girth a multiple regression equation was calculated from a sample of 110 angled female mature perch, the maximum girths of which had been measured specially for the purpose. The multiple correlation coefficient (measuring the success of estimating girth from length and weight jointly) was 0·957. The correlation coefficient of girth and length alone was 0·904, and of girth and weight alone 0·956. Thus, as was to be expected, the consideration of length was of less importance than weight in the estimation of maximum girth. Shown graphically (see Figure 4d), the truncation is bounded by lines of constant girth, which lie at an angle to the lines of constant weight (horizontal). The slopes of such lines can be calculated from multiple regression equations. For this sample it was found to be 15° 30′.

The difference between truncation by weight and truncation by girth, as shown in Figure 4d, is very small. For the perch sample the extent of this difference was calculated from the multiple regression equation and the length-weight regression equation. The difference in weight was found to be about 3 g. for fish in the weight range 50–80 g. Thus a plump fish of 72 g. would just be held by a mesh of 11·2 cm. circumference, whereas a longer,

thinner fish also weighing 72 g. could swim right through. Again, the plumper fish weighing 73 g. and 74 g. would be retained and the thinner would escape, but at 75 g. the net would retain all fish. This difference is clearly negligible, and it has therefore been concluded that the assumption of truncation by weight is adequate, even if in fact truncation is by girth.

V. Conclusions

It was found that a good approximation to the selective action of a gill-net was given by assuming that truncation was by weight. This conclusion was based on the assumptions that all the fish were meshed by the body and only one size of gill-net used. It was confirmed by comparing artificially truncated data with gill-netted samples. Data truncated in this way do not usually yield a satisfactory estimate of the population weight-length relationship (see Figure 4c and Table 1, rows 3, 5, and 9). Samples taken in a single size of gill-net can, however, sometimes do so, as the presence of very big or very small fish (well beyond the limits of selection by the circumference of the meshes) can alter the regression line considerably, resulting in an accurate estimate of the population regression slope (see Table 1, rows 1b and 8a).

If adequate data are obtained from at least two sizes of mesh, the effects of truncation on the regression line are very much reduced or even removed. Even if the individual regression lines for each size of net separately are significantly different from the population slope, the joint line calculated from combining the data can give an accurate estimate of the population value (see Table 1, rows 1a, 1b, and 1c).

In other words, an accurate estimate of the population weight-length regression coefficient can be obtained only when a relatively wide range of length is covered by the sample. This can occur either as a result of using gill-nets of two or more mesh-sizes or by chance catches of extreme sizes of fish in one mesh-size of gill-net. It is plain therefore that for char and perch a single mesh-size of gill-net cannot be relied upon to provide an accurate result.

Summary

The object of this paper is to consider whether a reliable estimate of the weight-length regression coefficient of a population of fish can be obtained from measurements of samples of fish caught in gill-nets.

A short description of materials and methods is followed by a comparison of the weight-length relationships of fish caught by gill-nets and other means. The effects on the calculated weight-length relationship of truncating a sample are discussed. Examples are given of artificial truncation of two populations of perch. The length-weight-girth relationship of a sample of perch has been analysed.

It is shown that for char and perch a satisfactory *estimate* of the population regression coefficient, which does not differ significantly from the *true* population regression coefficient, can be obtained when a relatively wide

range of length is covered by the sample. This can be achieved either by using gill-nets of two or more mesh-sizes or by chance catches of big or small fish in a gill-net of one mesh-size. In most cases catches from gill-nets of only one mesh-size do not give a reliable estimate of the population weight-length relationship.

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References

Farran, G. P., 1936. "On the mesh of herring drift-nets in relation to the condition factor of the fish". J. Cons. Internat. Explor. Mer, **11** (1): 43–71.

Le Cren, E. D., 1951. "The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*)". J. Anim. Ecol., **20** (2): 201–19.

Margetts, A. R., 1954. "The length-girth relationships in haddock and whiting and their application to mesh selection". J. Cons. Internat. Explor. Mer, **20** (1): 56–61.

Snedecor, G. W., 1946. "Statistical methods applied to experiments in agriculture and biology". 4th ed. Ames, Iowa.

Watson, J., 1925. "The English lake district fisheries". Foulis, Edinburgh.

Worthington, E. B., 1950. "An experiment with populations of fish in Windermere, 1939–48". Proc. Zool. Soc. Lond., **120**: 113–49.

The Length-Girth Relationships in Whiting and Cod and their Application to Mesh Selection

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Lengths and girths

Measurements of lengths and girths of cod and whiting, further to those published previously (MARGETTS, 1954), have been taken at sea during a fishing experiment. For each fish three measurements were recorded, overall length, natural girth, and constricted girth. The girth measurements were taken with a thin tape measure in the form of a noose, the so-called natural girth being that where the tape measure was close round, but in no way constricting, the position of maximum girth, wherever that may have been on the fish, and the constricted girth was represented by the smallest noose through which the fish could be gently eased with a pulling force estimated as being in the region of 2–2½ lb. The measurements were all made on freshly caught fish during daylight in August on the Scarborough Castle Ground in the North Sea.

The measurements of whiting are given in Table 1 and those of cod in Table 2. When all the girth measurements had been completed, the tape measure, which had already been checked before use, was again checked against a ruler and was found to have shrunk by 3 mm. in 20 cm. during the 1½ days in use. Exactly when the shrinkage occurred is not known; textile materials shrink fairly rapidly after first wetting, yet in this case the protective covering was only worn off with use. The best correction factor is thought to be about 2 mm. in 20 cm., or 1%, and this has been applied to the figures plotted in Figures 1 and 2, but not to the tabulated data.

The whiting dimensions, when plotted as mean girth at each centimetre length, fall on a straight line with little scatter of the points. The lines drawn in Figure 1 have been fitted by eye and their slopes are described by the equations: —

$$\text{length} = (\text{natural girth} \times 2{\cdot}11) - 1{\cdot}5$$
$$\text{and length} = (\text{constricted girth} \times 2{\cdot}32) - 0{\cdot}9$$

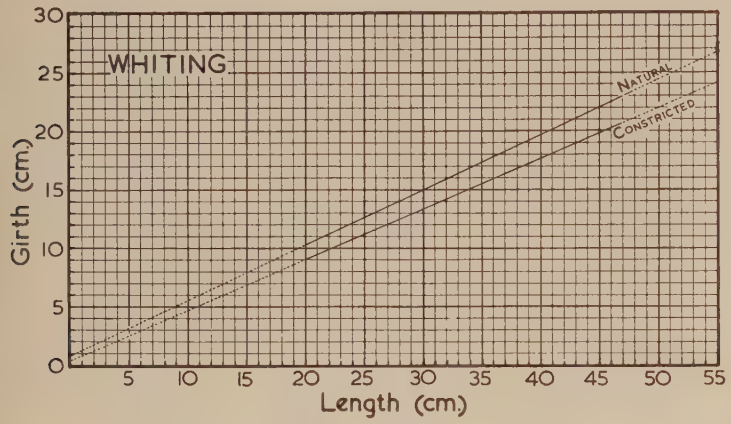

Figure 1. Length-girth relationship of whiting.

Table 1

Whiting length and girth measurements

Length cm.	Number of fish measured	Mean natural girth cm.	Mean constricted girth cm.
20	1	10·8	9·3
21	6	10·3	9·4
22	5	11·6	10·3
23	10	11·7	10·2
24	7	11·8	10·8
25	7	12·6	10·8
26	8	12·9	11·6
27	13	13·2	11·8
28	6	14·5	13·0
29	13	15·1	13·4
30	14	15·5	14·0
31	12	15·3	13·7
32	13	16·3	14·8
33	12	16·8	15·1
34	12	17·3	15·4
35	11	16·5	14·9
36	3	18·3	16·5
37	2	16·8	15·4
38	2	19·2	17·8
39	5	19·3	17·1
40	2	18·8	17·0
41	1	19·3	17·3
42	1	19·8	18·9
43	1	24·8	20·4
44	–	–	–
45	1	23·2	21·0
46	1	19·9	18·6

Table 2

Cod length and girth measurements

Length cm.	Number of fish measured	Mean natural girth cm.	Mean constricted girth cm.
18	1	9·6	9·1
19	3	10·3	9·8
20	1	10·4	9·3
21	4	11·0	10·6
22	1	11·7	10·1
23	4	12·4	11·5
24	7	13·1	12·1
25	9	13·0	12·2
26	6	13·7	12·7
27	9	14·1	13·1
28	6	14·5	13·5
29	9	15·2	14·2
30	6	15·6	14·7
31	3	16·0	15·1
32	5	16·8	16·1
33	5	17·4	16·3
34	4	17·2	16·4
35	1	18·4	16·8
36	3	18·9	18·0
37	–	–	–
38	4	19·4	18·2
39	2	21·2	19·8
40	2	21·3	20·8
41	1	19·4	17·8
42	1	22·3	21·5
43	–	–	–
44	1	23·5	21·4
45	3	21·3	20·6
46	4	24·1	23·2
47	2	23·0	22·0
48	1	25·3	24·6
49	3	26·5	25·1
50	1	27·0	25·7
51	2	26·2	24·8
55	1	27·7	26·2
61	1	30·3	29·6
64	2	33·4	32·1
73	1	38·0	34·6

This relationship is so close to direct proportionality that for practical purposes proportionality factors of 2·0 for natural girth and 2·23 for constricted girth can be used with reliability. The regression lines of length on girth, as fitted to the data by the method of least squares, are length = (natural girth × 1·98) + 0·99 and length = (constricted girth × 2·25) + 0·39.

The cod dimensions, when similarly plotted, also fall on a straight line with little scatter of points. The lines drawn in Figure 2, fitted by eye, show direct proportionality with the proportionality factors 1·93 for natural girth

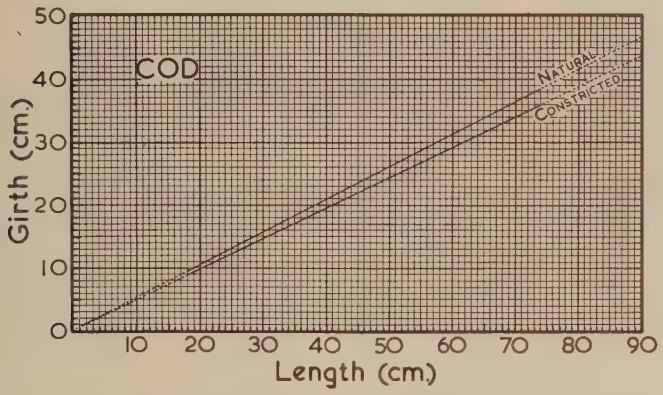

Figure 2. Length-girth relationship of cod.

and 2·06 for constricted girth. The regressions of length on girth as fitted by the method of least squares are: —

$$\text{length} = \text{natural girth} \times 1{\cdot}95$$
$$\text{and length} = (\text{constricted girth} \times 2{\cdot}03) + 0{\cdot}7$$

The whiting and cod measured were mostly with guts well filled with food. It was noticeable that this brought the position of constricted girth rather behind that of natural girth, while both were around the body of the fish as distinct from the opercular region. For cod, both positions were relatively a little further forward than for whiting. The natural girth measurements were, of course, affected by expansion of the air bladders, and because of this and with allowance for the activity of the fish in swimming through the meshes, the constricted girth measurements are considered to be of the greater practical value.

Mesh selection of whiting and haddock

A survey of these more recent whiting measurements together with the earlier ones of whiting and haddock in relation to known mesh selection of whiting and haddock by double-braided sisal and manila deep-sea trawl cod-ends reveals a remarkably constant relationship between the girth of the fish at 50% release length and the internal lumen perimeter measurement of the mesh giving that 50% release length (Table 3). For haddock (selection factor 3·3) the constricted girth at the 50% release length, expressed as a percentage of the mesh perimeter size, is calculated as 79%, and for whiting (selection factor 3·7), 79% from the earlier measurements and 80% from the more recent measurements.

The mesh perimeter size is estimated as being twice the stretched mesh-size measurement by internal gauge plus twice the 2 mm. thickness of the standard gauge.

Table 3

Relationship between girth size and trawl mesh selection in haddock and whiting

Species		Haddock	Whiting	
Selection factor		3·3	3·7	
50% selection length, 80 mm. trawl mesh (cm.)		26·4	29·6	
			earlier data	present data
Girth at 50% selection length	Natural girth (mm.)	135	144	148
	Constricted girth (mm.)	129	130	131·5
Percentage of 80 mm. mesh lumen (164 mm.) occupied by girth of 50% selection length fish	Natural girth	82	88	90
	Constricted girth	79	79	80

Mesh selection of cod

Cod are not very different in shape from whiting and haddock, and although they give the impression of being stronger swimmers, this impression is probably in part due to their usually larger size; in fact, size for size at the 26–30 cm. lengths considered here, cod are probably not much better able to escape meshes which would hold whiting and haddock. Thus, if the relationship between mesh shape and fish girth is assumed to be much the same for cod as for whiting and haddock, the percentage of the mesh perimeter taken up by the constricted fish girth at the 50% release length might be taken as 79%. Thus, for an 80 mm. mesh with 164 mm. perimeter, this would indicate a constricted girth at 50% release length of 130 mm. From the graph of length/girth for cod, this corresponds to a fish length of 26·8 cm. as the predicted 50% release length of cod by an 80 mm. mesh in a double sisal or manila trawl cod-end. The cross-sectional shape of a cod is, if anything, relatively rather wider than that of whiting and haddock so that this estimate is probably low. The indicated mesh selection factor for a double sisal trawl cod-end of approximately 80 mm. mesh is then at least 3·35, similarity being assumed between whiting, cod, and haddock as regards strength and shape.

Mechanics of mesh selection

It is noteworthy that in double-braided sisal and manila trawl cod-ends, as the constricted girth only occupies 80% of the mesh perimeter the meshes in action are obviously not distorted much from their roughly diamond shape to allow the passage of roundfish. In fact, as illustrated by the geometrical shapes in Figure 3, the amount of distortion of a double-braided sisal mesh from a true diamond shape needed to let through a haddock or whiting of 50% selection length is scarcely noticeable (Figure 3d). If there were such

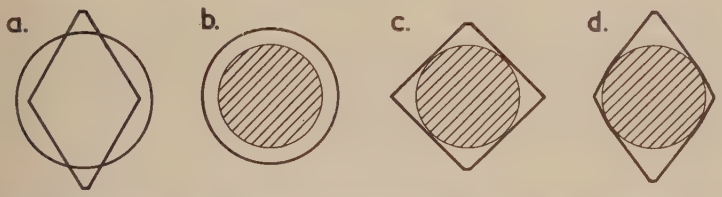

Figure 3. Diagrams to scale of hypothetical 80 mm. (on the gauge) mesh shapes and relation of mesh to the assumed circular cross-section of a whiting of constricted girth corresponding to the 50% selection length for an 80 mm. double-braided sisal trawl cod-end.

a. A perfectly flexible mesh of circular shape and a rigid mesh of true diamond shape, both of the same size on the gauge.
b. Fish in a perfectly flexible circular mesh.
c. Fish in a square mesh.
d. Fish in a slightly flexible diamond-shaped mesh.

a thing as a perfectly flexible mesh, and this were to take up the girth-shape of a fish, then a whiting of an assumed circular cross-section, even when slightly "blown" due to being hauled up from a considerable depth, would theoretically be able to swim through it without touching it, leaving a gap of 2·6 mm. all round between fish and the sides of an 80 mm. mesh; the gap between the perfectly flexible mesh and the constricted girth of a whiting would be 5·3 mm. (Fig. 3b). The circular cross-section is assumed for simplicity; the natural cross-section of a whiting tends to be oval, but the constricted cross-section is more nearly circular. A rigid-sided diamond mesh would, on this assumption, not allow a whiting at the 50% selection length of double sisal trawl cod-end mesh to pass. It is interesting to note that the sides of a rigid, square, 80 mm. mesh are very nearly tangential to the circular cross-section of a constricted whiting (Fig. 3c).

So far, meshes have for theoretical purposes been assumed to be either rigid diamonds or completely flexible. In fact meshes are not perfectly flexible, neither are they absolutely rigid, nor are they of true diamond shape. The very way in which hand-braided netting is constructed does not allow meshes to take up a true diamond shape, although a mesh of thin flexible twine may come very close to a true diamond shape. A mesh has four knots at its corners, and from each knot lead two sides of the mesh, hence there are eight emergences of twine from knots (this takes no account of double braiding where two twines always run together side by side). Inspection of a piece of netting shows that in any one mesh, of the eight emergences of twine from knots, six are in direction more or less along the length of the netting and two are at right angles to it. Opening the mesh thus requires bending the twine to take up the slopes of the mesh sides; the thicker and stiffer the twine, the more of the inter-knot mesh side is taken up in curvature before the true slope of the mesh side is attained. This curvature means distortion of the mesh from the true diamond shape and the result is that, in netting of stiff twine, in each mesh two adjacent sides are rather concave and two rather convex. This will not be noticeable in big meshes of thin twine, but is most marked in smaller meshes of new, thick, stiff twine. Furthermore the shape of the cross-section of the fish is not strictly circular

and the body, particularly the belly, of the fish is pliant enough to take up to some extent the shape of the opening through which it is passing. Hence when a whiting of size corresponding to the 50% selection length of a particular mesh tries to pass through that mesh, it is to be expected that, if the mesh is not a small one of stiff twine, the sides of the mesh will be very slightly bowed outwards from their normal roughly diamond shape and the fish will more or less take up the general shape of the mesh.

Considered from the purely mechanical point of view, the case of the relationship between the rigid diamond mesh and the constricted girth of the fish represents, in terms of fish size, the lower limit of net selectivity, while that between the perfectly flexible mesh and the constricted girth of the fish represents the upper limit of selectivity. Double-braided thick twines, such as especially manila and sisal, tend to give the rigid mesh while single-braided thin twine, such as cotton and nylon, tend to give the perfectly flexible mesh.

It has been shown above that, for an 80 mm. mesh of double-braided sisal, the firmly constricted girth of whiting and haddock is almost 80% of the perimeter of the mesh lumen. Therefore, at the same mesh size, the selectivity of nets made of thinner and more flexible single-braided twines cannot be more than 25% higher than that of the double-braided sisal. As the length of a whiting or haddock is proportional to its constricted girth, then this 25% maximum will apply also to the selection factor for the species. For example, if the factor for haddock in an 80 mm. double-braided sisal cod-end is 3·2 (see Report of *ad hoc* Committee) then the very highest factor for a cod-end of lighter build cannot possibly exceed 4·0, and if the 80 mm. double sisal selection factor for whiting is 3·7, it cannot exceed 4·6 in an 80 mm. lighter net. In fact, as meshes of single cotton or nylon in action are not perfectly flexible, the factor for the lighter net must be less than 25% above that for a double sisal trawl. It is important that the mesh size should not be neglected in such considerations, because — apart from the deviation from the true diamond shape inherent in netting — the thicker the twine and the smaller the mesh, the greater is the proportion of the mesh size taken up by the side knots and hence the more rigid the mesh. Thus it is reasonable to expect that mesh selection factors, for nets of particular materials and braided in particular ways, depend to some extent upon the size of mesh, the selection factor tending to increase with mesh size, particularly over the range of smaller mesh sizes. Also it is reasonable to expect that the speed at which the net passes through the water, and hence the tension in its meshes, affects the rigidity of the netting and hence its selectivity.

Summary

The lengths and girths (both natural and constricted) of freshly caught whiting and cod were measured.

For both whiting and cod the length-girth relationship is shown to be linear and proportional or nearly so. The proportionality factors relating length and natural girth are for whiting 2·0 and cod 1·93, and those relating length and constricted girth are for whiting 2·23 and for cod 2·06.

Constricted girths are considered to be of the greater practical value.

At the 80 mm. double sisal trawl cod-end mesh 50% selection lengths of haddock and whiting the constricted girth measurements represent about 80% of the internal lumen perimeter of the mesh as measured on the gauge.

On the assumption that cod resemble haddock and whiting, a mesh selection factor of not less than 3·35 is indicated for cod in a double sisal trawl cod-end.

Some physical aspects of the relationship between a mesh and an escaping fish are considered. It is shown that little distortion of a stiff mesh is needed to let whiting at the 50% length pass through; in comparison there is plenty of room for bigger fish to escape through a light flexible mesh of the same size on the gauge. It is suggested that mesh selection factors for any specified gear and material and mode of construction of meshes vary with the size of mesh.

A Trawling Survey off the Gold Coast[1)]

By

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Part of the work of the West African Fisheries Research Institute was to explore the whole of the West African continental shelf for potential trawling grounds and to determine the possibilities of such grounds for future exploitation. The present paper gives the results of a survey made off the Gold Coast in May and June 1956 with the research vessel "Cape St. Mary", a diesel trawler of 100-ft. overall length. The area was chosen to provide information for the Gold Coast Fisheries Department, which is investigating the possibilities of developing a fishing industry based on the new port of Tema.

Although the results of this work refer only to conditions during the dry season, they are significant in that they suggest an ecological structure on the Gold Coast shelf which is almost identical with that described by Postel (1955b) for the same season on the French Guinea shelf. Yet these areas are a thousand miles apart and the Guinea shelf is more than 70 miles wide compared with 14 miles at Tema. It may be, therefore, that the same or a similar description will hold good for a good deal of the West African shelf in addition to the small areas already studied.

Methods

The survey covered the whole of the continental shelf for a distance of 20 miles on either side of the port of Tema. Trawl hauls were made in depths of approximately 10, 20, 30, 50, 100, and 200 fathoms at 8-mile intervals along the shelf. In this way samples were obtained at approximately equal distances along and across the shelf and at a variety of depths. Figure 1 shows the positions of the 58 hauls made. Except for 2-hr. hauls at 200 fathoms, all were of 1-hr. duration. One day and one night haul were made at each station, except at the depths of 100 and 200 fms., where the night hauls were omitted. On the most westerly positions (section A) at least

[1)] Now Ghana. Ed.

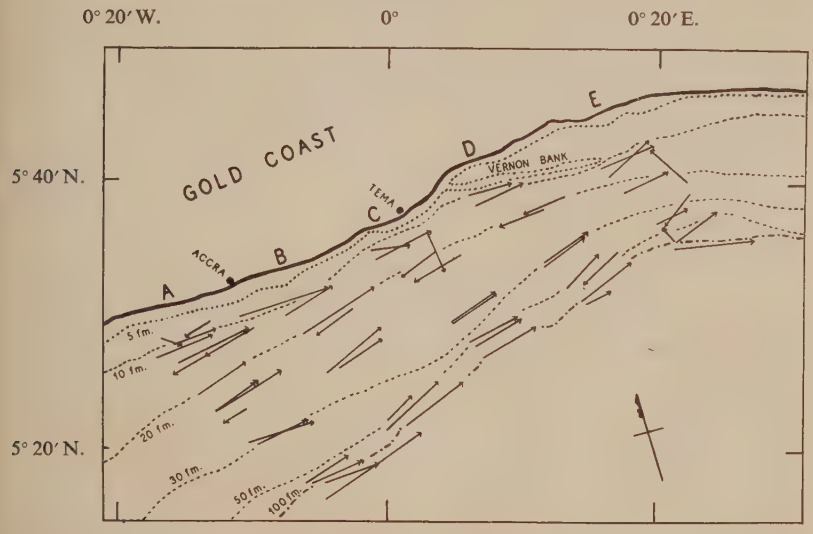

Figure 1. Sketch chart of the Tema area showing the sections investigated with the positions and directions of the hauls. Depth contours are in fathoms.

three daylight hauls were made at each station in an endeavour to obtain a measure of the variation in rate of catch for the same locality. The gear used was a Peter Carey trawl, with a 72-ft. headrope, 10 ft. legs, 15 ft. sweeps, and Dan Lenos with rollers. Cod-ends were of double manila twine 100/3, and of 3-inch mesh stretched knot to knot. All the hauls were made with same gear, towed at the same engine speed, but in varying relation with the state of the tide. The only change made in the gear was the substitution of a light for a heavy chain on the footrope, so that the trawl would pick up less of the prevalent gorgonian coral. On three sections (A, C, E, Fig. 1) bottom temperatures were obtained with a Nansen-Pettersson bottle at stations situated on the 5, 10, 20, 30, and 50 fm. contours.

Results

1. Nature of the bottom

The whole region between the 10 and 50 fm. depth contours has a rocky bottom with patches of sand and mud. The rock is covered with red and yellow gorgonian coral. Hard and soft corals are often found in the deeper parts and bryozoans occur sporadically throughout the area. Occasional large catches of echinoderms associated with small catches of flatfish indicate the presence of areas of sand and mud. In the north-eastern corner of the area there is a bank (Vernon Bank), hauls on and around which yielded considerable quantities of a brown seaweed. Below the 50-fm. line the bottom changes to soft mud. The rocky nature of the bottom resulted in much

Table 1

Results of repeated hauls at stations on Section A

Depth in fathoms	Rate of catch in Kg./hr. Haul No. 1	2	3	4	5	6
10.....	63·2	195·9	59·3	22·7	187·3	29·9
20.....	107·1	27·7	10·6	–	–	–
30.....	74·6	70·6	30·2	37·0	–	–
50.....	14·7	68·4	73·9	–	–	–

Table 2

Results of day trawling in the Tema area

Depth in fathoms	Rate of catch in Kg./hr. (One haul) Section A[1])	B	C	D	E
10.....	63·2	197·9	68·5	37·1	107·1
20.....	107·1	182·2	58·0	13·7	59·7
30.....	74·6	113·4	122.6	24·5	94·0
50.....	14·7	142·8	18·5	31·1	24·7
100.....	13·8	9·6	181·8	251·5	60·6
200.....	1·65	–	–	0·0	–

[1]) First haul only.

Table 3

Results of night trawling in the Tema area

Depth in fathoms	Rate of catch in Kg./hr. (One haul) Section A	B	C	D	E
10.....	39·8	305·9	16·2	206·9	70·8
20.....	102·9	224·0[1])	201·0	187·6	153·3
30.....	–	8·1	149·1	146·7	74·7
50.....	–	146·5	59·9	84·8	96·8

[1]) First of two hauls, the second giving a rate of 70·4 Kg./hr.

damage to the nets. In 58 1-hour hauls, the nets were badly torn on 15 occasions; on 2 occasions the whole trawl was lost, the belly of the trawl was destroyed twice, and a single wing lost once.

2. Rate of catch

Table 1 shows the rates of catch for daylight hauls grouped according to depth on the most westerly section (A). Tables 2 and 3 show similar information for all the sections for day and night fishing respectively. The rates of catch given in these tables are based on single hauls. Where more than one haul was made (on section A in 10–50 fms., and on section B in 20 fms.) the rate is based on the first haul only. Together these tables show the results for all the hauls made in the Tema area.

Several points of interest emerge from these tables. Firstly, the ranges in the rates of catch in the same locality (Table 1) and at different positions (Table 2) are similar. Secondly, the range in the rates of catch at different depths (excluding 200 fms.) is of the same order as the range in the values for different positions (Table 2). Thirdly, the rates of catch for night fishing,

for the inshore 20 fms. at least, seem larger than the comparable values for day fishing (Tables 2 and 3). Fourthly, in all cases the variability in rate of catch is considerable. (The difference in weight of the chain on the footrope did not appear to affect the catches in any significant way and this factor has therefore not been considered in the tables of rates of catch.) As can be seen from Tables 1–3, the results are too few and too variable to allow any useful comparison of the rates of catch at different positions and depths. However, with the exception of the Vernon Bank area, the nature of the bottom does not change in any important respect along this part of the continental shelf, but it does change with increasing depth across the shelf. Furthermore, analysis of the proportional occurrence of fish species at the various stations shows a change in the fish fauna which is associated with the depth of haul rather than with the position of the stations along the Tema area. In order to summarize the data on rate of catch so that they can be related to these two observations on the nature of the bottom and the fish species, the results have been grouped according to depth of haul, and into day and night catches. The latter have been separated because of their possibly significant differences. Table 4 shows the results, grouped in this way, in terms of effort, catch, and rate of catch. The mean rates of catch for each depth suggest that there are differences in the amount of fish caught at different depths.

Table 4

Rate of catch analysis for the Tema area

Depth in fathoms	Day fishing				Night fishing			
	Number of hauls	Total time hrs. mins.	Total catch Kg.	Rate of catch Kg./hr.	Number of hauls	Total time hrs. mins.	Total catch Kg.	Rate of catch Kg./hr.
10.....	10	9·30	937·2	98·6	5	5·00	639·5	127·9
20.....	7	7·00	459·0	65·6	6	6·00	939·0	156·6
30.....	8	7·35	527·6	69·6	4	4·00	378·6	94·6
50.....	7	6·30	302·6	46·5	4	4·25	420·2	97·0
100.....	5	5·00	517·3	103·5	–	–	–	–
200.....	2	2·20	3·3	1·4	–	–	–	–
Total...	39	37·55	2,747.0	72·4	19	19·25	2,377·3	122·3

Depth in fathoms	Total day and night fishing			
	Number of hauls	Total time hrs. mins.	Total catch Kg.	Rate of catch Kg./hr.
10.....	15	14·30	1,576·7	108·8
20.....	13	13·00	1,398·0	107·5
30.....	12	11·35	906·2	78·8
50.....	11	10·55	722·8	66·2
100.....	5	5·00	517·3	103·5
200.....	2	2·20	3·3	1·4
Total...	58	57·20	5,124·3	89·4

The results have been grouped according to the depth of haul, and the table shows the trawling effort in terms of the number of hauls and their total duration, the total catch in Kg. and the rate of catch in Kg./hr. for day and night fishing separately and for all the hauls combined.

3. Species analysis

The nature of the catches is best shown in two ways. Firstly, Table 5 illustrates the distribution and frequency of occurrence of species which are of economic importance in that they are present in quantities of 1 Kg. or more in 25% or more of all the hauls at each particular depth. Secondly, Table 6 shows the distribution of species which are of ecological significance in that they are invariably present at a particular depth, as indicated by their appearance, regardless of quantity, in 75% or more of all the hauls at that depth. Table 7 shows the importance by weight of those species which contributed to 2% or more by weight of the total catch at each depth. The numbers of fish of each of these species are also indicated in this table, but in most cases some estimate of numbers from average sizes had to be made to provide these values, which are not therefore a statement of the precise numbers of fish in the catches. They provide a guide, nevertheless, to the average size of the various species, and the total numbers and weights of fish for each depth show the general decrease in size of species with increase in depth. The last figures also show that the numbers of fish in the catches tend to increase with increase in the depth of haul and that this tends to offset the effect of small size on the total weight of fish caught.

In Tables 5–7 the various fish families (cf. Cadenat, 1950) have been included, together with the larger systematic groups of sharks (Pleurotremata), skates and rays (Hypotremata), and flatfish (Heterosomata), in order to indicate their relative importance in the Tema area. Catches of individual species of sharks, skates, rays, and flatfish were usually too poor to warrant separate treatment. In these tables the figures relate to all the hauls made in the Tema area for both day and night fishing.

Discussion

For the purposes of fishery development the rates of catch obtained in the region investigated off the Gold Coast must be compared with those obtained in other parts of the world, especially tropical regions. Such comparisons are difficult to make because there are considerable differences in boats, equipment, and general technique which may cause profound differences in catching power. Whiteleather and Brown (1945) quote rates of catch from Egypt, Western Australia, and Peru of 49–116 Kg./day, 4 cwt./hr., and 431 lb./hr. respectively. They themselves record mean rates for the Gulf of Paria and British Guiana of 315 and 291 lb./hr. respectively, according to locality and season. In eastern Australia the rate of catch for trawlers has varied between 2·1 and 6·8 cwt./hr. during the period 1918–1942 (Fairbridge, 1948). The "William Carrick", working from Bombay, had an average catch of 116 lb./hr., or 80 lb./hr. excluding sharks and rays, with rates of between 21 and 145 lb./hr. according to locality (Hefford, 1923). Catches at the rate of 200 to 500 lb./hr. have been obtained in the Great Australian Bight (Houston, 1954). It can be seen, therefore, that the rates of catch for the Gold Coast compare favourably with those from other tropical waters and the rates for inshore fishing rank with the best elsewhere.

Table 5

Distribution with depth of economically important fish species in the Tema area

The table shows the number of hauls in which more than 1 Kg. of the species occurred, expressed as a percentage of the total number of hauls at that depth.

	Percentage frequency of occurrence (values greater than 25% only)				
Depth in fathoms: –	10	20	30	50	100
Species					
Otolithus macrognathus BLEEKER	33	–	–	–	–
Ephippus lippei STEINDACHNER	27	–	–	–	–
Drepane africana OSORIO	67	–	–	–	–
Scoliodon terrae-novae RICHARDSON	53	–	–	–	–
* *Hemiconiatus guttifer* BENNETT	47	–	–	–	–
Balistes forcipatus GMELIN	27	–	–	–	–
Galeoides decadactylus BLOCH	33	–	–	–	–
Lethrinus atlanticus CUV. VAL.	33	31	–	–	–
* *Ostracion tricornis* LINNÉ	40	54	–	–	–
Lutjanus maltzani STEINDACHNER	47	38	33	–	–
Pagrus ehrenbergii CUV. VAL.	60	77	67	36	–
Lutjanus guineensis BLEEKER	–	38	–	–	–
Epinephalus aeneus GEOFF. ST. HILAIRE	–	54	58	–	–
Cephalacanthus volitans LINNÉ	–	46	33	–	–
Pagellus sp. aff. *P. erythrinus* LINNÉ	–	31	75	82	40
Otoperca aurita CUV. VAL.	–	–	50	27	–
Selar crumenophthalmus BLOCH	–	–	25	27	–
* *Lepidotrigla cadmani* REGAN	–	–	42	64	80
Priacanthus arenatus CUV. VAL.	–	–	–	45	–
Umbrina canariensis VAL.	–	–	–	27	40
Sciaena sp.	–	–	–	25	80
Dentex congoensis POLL	–	–	–	36	60
* *Antigonia capros* LOWE	–	–	–	–	60
Smaris macrophthalmus CADENAT	–	–	–	–	60
Scomber colias LOWE	–	–	–	–	60
* *Trigla lyra* LINNÉ	–	–	–	–	40
Hypoclydonia bella GOODE & BEAN	–	–	–	–	40
Sp. indet.	–	–	–	–	40
Families etc.					
Ephippidae	40	–	–	–	–
Drepanidae	67	–	–	–	–
Lutjanidae	47	54	31	–	–
Serranidae	–	–	54	–	–
Sciaenidae	47	–	–	36	60
Pomadasidae	47	38	62	30	–
Sparidae	60	77	92	100	80
Flatfish (Heterosomata)	–	46	33	27	40
Skates and Rays (Hypotremata)	60	77	–	64	40
Sharks (Pleurotremata)	80	–	83	45	40

*) Non-marketable species.

Indeed, they are higher than the rates given by WHEELER (1953) for the North Sea, and those for the Patagonian shelf, where rates of 27 to 66 Kg./hr. were obtained by the "William Scoresby" (HART, 1946).

A close comparison between the Tema area and the French Guinea

Table 6

Distribution with depth of ecologically significant fish species in the Tema area

The table shows the number of hauls in which a species was present, expressed as a percentage of the total number of hauls at that depth.

	Percentage frequency of occurrence (values greater than 75% only)				
Depths in fathoms: –	10	20	30	50	100
Species					
Hemiconiatus guttifer BENNETT	87	–	–	–	–
Syacium micrurum RANZANI	80	100	–	82	–
Chilomycterus antennatus CUVIER	–	85	–	–	–
Chaetodon luciæ ROCHEBRUNE	–	77	–	–	–
Epinephalus aeneus GEOFF. ST. HILAIRE	–	77	100	–	–
Upeneus prayensis CUV. VAL.	–	77	92	–	–
Pagrus ehrenbergii CUV. VAL.	–	92	84	–	–
Raia miraletus LINNÉ	–	92	100	–	100
Cephalacanthus volitans LINNÉ	–	–	83	–	–
Torpedo torpedo LINNÉ	–	–	83	100	–
Pagellus sp. aff. *P. erythrinus* LINNÉ	–	–	92	82	–
Priacanthus arenatus CUV. VAL.	–	–	83	81	–
Lepidotrigla cadmani REGAN	–	–	100	100	80
Sciaena sp.	–	–	–	–	100
Dentex congoensis POLL	–	–	–	–	80
Antigonia capros LOWE	–	–	–	–	100
Scomber colias LOWE	–	–	–	–	80
Sp. indet.	–	–	–	–	100
Families etc.					
Flatfish (Heterosomata)	93	100	83	82	80
Sparidae	87	100	100	100	100
Skates and Rays (Hypotremata)	100	100	–	100	80
Sharks (Pleurotremata)	80	–	100	–	–
Pomadasidae	–	–	79	85	–
Sciaenidae	–	–	–	–	100

shelf is possible, because of the work of POSTEL. He obtained rates of catch of 200–300 Kg./hr. in 5–10 fms., 100 Kg./hr. in 10–25 fms., and 160 Kg./hr. in 50–100 fms. Between 25 and 50 fms. he found the ground too rough for trawling. The comparable figures for the Tema area are 100 Kg./hr. in 10 and 20 fms., 80 and 70 Kg./hr. in 30 and 50 fms., and 100 Kg./hr. in 100 fms. This correspondence between the two localities also extends to the nature of the bottom and its associated fauna, and to the nature and distribution of fish species. Close inshore the bottom is mainly mud with some sand, changing below 10 fms. to rocks with patches of sand and mud and becoming soft mud below 50 fms. The invertebrate material trawled off Tema may be said, provisionally, to be similar to that described by POSTEL for French Guinea. Gorgonids, bryozoans, and sponges are common at 10 fms., together with *Neptunus validus* and *Oreaster clavatus*, and they extend to 50 fms., with true corals occurring below 25 fms. At 100 fms. holothurians and squids are common. The whole of the sea floor from 10 to 50 fms. in the Tema area appears to be rocky, with a covering of red and yellow gorgonian coral.

Table 7

The table lists, for each depth, the weights of those species which formed more than 2% by weight of the total catch at that depth. The numbers of fish are also given but in most cases some estimates were made from average sizes in order to obtain these values, which are not therefore a statement of the precise numbers of fish in the catches.

Species	Weight in Kg. (*Number of fish*)									
Depth: –	10 fm.		20 fm.		30 fm.		50 fm.		100 fm.	
Otolithus macrognathus BLEEKER	109	(*245*)	–		–		–		–	
Galeoides decadactylus BLOCH	46	(*330*)	–		–		–		–	
Pomadasys jubelini (CUV. VAL.)	73	(*127*)	–		–		–		–	
Drepane africana OSORIO	473	(*1,546*)	103	(*335*)	–		–		–	
Hemiconiatus guttifer BENNETT	101	(*56*)	36	(*14*)	–		–		–	
Ostracion tricornis LINNÉ	66	(*565*)	120	(*909*)	–		–		–	
Scoliodon terrae-novae RICHARDSON	67	(*29*)	56	(*28*)	–		–		–	
Lutjanus maltzani STEINDACHNER	122	(*136*)	63	(*70*)	81	(*34*)	–		–	
Pagrus ehrenbergii CUV. VAL.	127	(*375*)	159	(*901*)	227	(*648*)	62	(*74*)	–	
Epinephalus aeneus GEOFF. ST. HILAIRE		–	75	(*64*)	157	(*57*)	55	(*118*)	–	
Lutjanus guineensis BLEEKER		–	63	(*32*)		–		–	–	
Balistes forcipatus GMELIN		–	52	(*131*)		–		–	–	
Ephippus goreensis CUV. VAL.		–	36	(*82*)		–		–	–	
Lethrinus atlanticus CUV. VAL.		–	39	(*147*)		–		–	–	
Plectorhynchus mediterraneus (GUICHENOT)		–	35	(*72*)	35	(*59*)		–	–	
Cephalacanthus volitans LINNÉ		–	45	(*240*)	31	(*180*)		–	–	
Pagellus sp. aff. *P. erythrinus* (LINNÉ)		–	58	(*647*)	152	(*1,844*)	103	(*2,068*)	–	
Pomadasys incisus BOWDICH		–		–	19	(*135*)		–	–	
Otopercа aurita CUV. VAL.		–		–	42	(*709*)	29	(*574*)	–	
Dentex congoensis POLL		–		–		–	92	(*2,798*)	33	(*531*)
Priacanthus arenatus CUV. VAL.		–		–		–	38	(*791*)	–	
Lepidotrigla cadmani REGAN		–		–		–	42	(*1,524*)	20	(*410*)
Umbrina canariensis VAL.		–		–		–	21	(*136*)	48	(*312*)
Selar crumenophthalmus BLOCH		–		–		–	17	(*342*)	–	
Sp. indet.		–		–		–	17	(*403*)	18	(*386*)
Sciaena sp.		–		–		–		–	110	(*1,034*)
Smaris macrophthalmus CADENAT		–		–		–		–	94	(*1,387*)
Antigonia capros LOWE		–		–		–		–	73	(*4,437*)
Scomber colias LOWE		–		–		–		–	26	(*258*)
Hypoclydonia bella GOODE & BEAN		–		–		–		–	11	(*285*)
Flatfish (Heterosomata)	27	(*181*)	60	(*745*)	28	(*362*)	34	(*155*)	6	(*123*)
Skates and Rays (Hypotremata)	99	(*206*)	122	(*322*)	70	(*264*)	63	(*175*)	9	(*42*)
Sharks (Pleurotremata)	39	(*15*)	51	(*24*)	23	(*19*)	45	(*24*)	42	(*14*)
Remainder	228	(*1,707*)	225	(*1,899*)	41	(*1,483*)	105	(*1,721*)	27	(*766*)
Total catch	1,577	(*5,518*)	1,398	(*6,662*)	906	(*5,794*)	723	(*10,903*)	517	(*9,985*)

POSTEL found a distinct change in the fish fauna in the 10–25 fm. zone. Typical estuarine species such as *Arius gambensis* BOWDICH, *Otolithus macrognathus* BLEEKER, *Drepane africana* OSORIO, *Ephippus lippei* STEINDACHNER, *Ephippus goreensis* CUV. VAL., *Galeoides decadactylus* BLOCH, and species such as *Hemiconiatus guttifer* BENNETT, *Otoperca aurita* CUV. VAL., and *Cynoglossus goreensis* STEINDACHNER occur inshore of the 10-fm. line. Below 10 fms. the estuarine species disappear and are replaced by red and brown types such as *Pagrus ehrenbergii* CUV. VAL., *Lethrinus atlanticus* CUV. VAL., *Lutjanus guineensis* BLEEKER, *Epinephalus aeneus* GEOFF. ST. HILAIRE, and *Upeneus prayensis* CUV. VAL. Examination of Table 5 shows that this description of the fish fauna of French Guinea will serve in every respect for that of the Tema area. The agreement is almost complete, even to the species. POSTEL's lists of the less important species in his catches also show considerable similarity with comparable lists for Tema (Table 6).

The results of the present work show that in addition to the fairly sharp change in fish species at 10 fms., there is a more subtle change which takes place in the 20 to 100 fm. zone. This is well shown in Tables 5 and 6, where it can be seen that as depth increases a gradual change occurs in the predominant species. Species such as *Pagrus ehrenbergii* CUV. VAL., *Lutjanus maltzani* STEINDACHNER, *L. guineensis* BLEEKER, and *Epinephalus aeneus* GEOFF. ST. HILAIRE give place to species such as *Pagellus* sp. aff. *P. erythrinus* LINNÉ, *Priacanthus arenatus* CUV. VAL., *Dentex congoensis* POLL, *Selar crumenophthalis* BLOCH, and *Lepidotrigla cadmani* REGAN, and these in turn are replaced at 100 fms. by *Antigonia capros* LOWE, *Scomber colias* LOWE, *Hypoclydonia bella* GOODE & BEAN, *Smaris macrophthalmus* CADENAT, and *Trigla lyra* LINNÉ. From the fishery point of view this change is very important because the species become of smaller average size and lower commercial value with increasing depth (cf. Table 7). At 200 fms. a few coryphenids and stomiatids were trawled but too few hauls were made for any definite information to be obtained.

It is possible, therefore, to divide the continental shelf off Tema into regions similar to those POSTEL has described for the Guinea shelf. An inshore region (0–10 fms.) is characterized by a mud bottom, water of high temperature (Figure 2), and an "estuarine fauna" (eurythermal and euryhaline species) which provides the best fishing in both quantity and quality of species. The extent of this region at Tema is small compared with the equivalent area in French Guinea. An offshore region (10–50 fms.) has a rocky bottom with its associated invertebrate fauna of gorgonids, sponges, and bryozoans. The fish fauna is characterized by red and brown species, which deteriorate in quality and perhaps in quantity towards the deeper parts of the region (Tables 4, 5, and 6). The existence of patches of sand and mud is indicated by sporadic catches of echinoderms and flatfish. The temperature also decreases as depth increases, with a rapid change in the 10–25 fm. zone, which perhaps marks the change in conditions between the inshore and offshore regions (Figure 2). The best fishing of the offshore region is found in this transition zone. From 25 to 50 fms. there is a variety of species which are small but reasonably abundant, so that catches are of moderate weight. A third region (50–100 fms.), which is really the edge

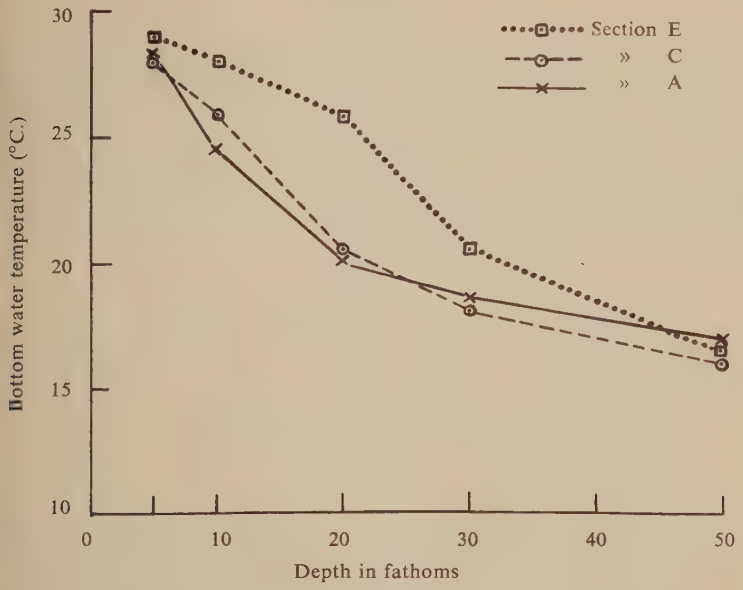

Figure 2. Bottom temperatures along three sections in the Tema area.

and the upper slopes of the shelf, is characterized by a mud bottom. In this zone the shelf species give place to deep-water species and the catches suggest the presence of large numbers of small fish (Table 7). Below 100 fms. the fauna may be abyssal but no satisfactory samples were obtained.

The correspondence between this description and that of POSTEL suggests that it can stand as a general description for at least the greater part of the West African shelf. An extensive trawling and hydrographic survey of the West African coast from Dakar to the Cameroons was made by the "Cape St. Mary" in 1952–53. The results of this survey, though it was not very intensive, tend to support this generalization. Hydrographic data from this survey and from French Guinea (POSTEL, 1955a) show that the salinity of the surface and inshore water tends to be relatively low during the wet season. This may account for the dominance of euryhaline fish species in the inshore region.

Acknowledgements

I should like to thank R. S. WIMPENNY for helpful suggestions with the manuscript, and S. C. JOHNSON of WAFRI who assisted throughout the work. D. GAULD and J. BUCHANAN of University College, Achimota, named the invertebrates. Finally, I would like to thank the Director of WAFRI for permission to publish this work.

Summary

The results of a trawling survey of a 40-mile length of the continental shelf off the Gold Coast are presented in terms of the rates of catch and the occurrence of species at different depths. The nature of the bottom and the associated invertebrate and fish fauna are briefly described and compared with similar information already available for the French Guinea shelf. The similarity in the descriptions of the ecology of these two areas is emphasized and the possibility that a similar description may be generally applicable to much of the West African shelf is discussed.

References

Cadenat, J., 1950. "Poissons de mer du Sénégal." Inst. Français d'Afrique Noire, Initiations Africaines, **3**.

Fairbridge, W. S., 1948. "The effect of the war on the East Australian trawl fishery". J. Coun. Sci. Industr. Res. Australia, **21**: 75–98.

Hart, T. J., 1946. "Report on trawling surveys on the Patagonian continental shelf". Discovery Rep., **23**: 223–408.

Hefford, A. E., 1923. "Report of the work of the steam trawler 'William Carrick'. May 1921 to February 1922." Dept. Industr., Government of Bombay. Government Central Press, Bombay.

Houston, T. W., 1954. "Commercial trawling tests in the Great Australian Bight, 1949–52." CSIRO, Australia, Div. Fish., Tech. Pap., 2.

Postel, E., 1955 a. "Observations hydrologiques au large des côtes d'A.O.F. Guinée, Décembre 1952 – Mars 1953." Cons. Internat. Explor. Mer, Rapp. et Proc.-Verb., **137**: 5–6.

Postel, E., 1955 b. "Les faciès bionomiques des côtes de Guinée Française." Cons. Internat. Explor. Mer, Rapp. et Proc.-Verb., **137**: 10–13.

Wheeler, J. F. G., 1953. "The bottom fishes of economic importance." In "Report on the Mauritius-Seychelles fisheries survey, 1938–1949." Colonial Off., Fish. Publ., **1** (3).

Whiteleather, R. T., & Brown, H. H., 1945. "An experimental fishery survey in Trinidad, Tobago and British Guiana, with recommended improvements in methods and gear." Anglo-American Caribbean Comm. U.S. Government Printing Office, Washington.

On the Growth of Eels in the IJsselmeer

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Large numbers of eels (*Anguilla vulgaris* Turt) have been able to thrive in the IJsselmeer, the freshwater lake created by the enclosure of the Zuiderzee, and fair catches of this valuable fish have been made there. For efficient management of the fishery, however, it is necessary to have as accurate information as possible about the growth of the eels, and the results of an investigation made to obtain this information are recorded here. As the great majority of the eels in the lake are males, this paper deals mainly with the growth of male eels.

Many studies of eel growth in various localities have already been made (e.g., Rasmussen, 1952; Rahn, 1955) and nearly all of them utilized the annual rings in otoliths or scales (or both together). In our studies we have used the annual rings in the otoliths. Small otoliths were dipped in creosote and examined by reflected light. Larger otoliths were first placed on a piece of hard rubber and polished with a wet, soft stone. The otoliths of more than 12,000 eels have been examined in this way and many others have been measured during the course of the investigation.

In order to obtain good samples of the eel population in the lake, we used a small-meshed trawl made of sarran, with which it was possible to catch elvers and eels of all sizes, and in our opinion the size distribution in the samples was a fair representation of the composition of the stock.

We fished with this trawl during the course of several summers. All the eels caught were measured and length-frequency tables were drawn up for each summer; these show the modal lengths of the youngest year-classes very distinctly. A comparison of length-frequencies for successive summers shows immediately the gradual shift of the mode. By this simple method we have already learned a good deal about the growth of the youngest stages (cf. Table 1). When studying this table, one must remember that eels are still growing a little in September and October; accordingly the lengths at the end of a summer lie in fact between those we observed in September

Table 1

The length-frequency of eels which entered the IJsselmeer as elvers in 1952, expressed as percentages of the total catch of eels with the small-meshed trawl. The figures in the first column refer to elvers only

cm.	1952				1953			1954			
	6–V %	17–VI %	22–VII %	4–IX %	26–VI %	23–VII %	22–IX %	2–VI %	8–VII %	3–VIII %	14–IX %
6	36·2	0·9	–	–		–	–	–	–	–	–
7	**60·5**	16·5	3·5	–			–	–		–	–
8	3·3	**18·6**	13·1	0·9	–			–	–	–	–
9	–	1·9	**14·7**	4·1	1·8	–	–	–	–	–	–
10	–	1·2	5·7	12·5	6·8	–	–	–	–	–	–
11	–	–	1·4	**15·8**	11·4	2·5	–	–	–	–	–
12		–	–	13·9	**15·9**	4·7	6·0	–	–	–	–
13	–	–	–	9·3	12·3	8·0	6·4	4·1	–	–	–
14				4·5	9·1	11·2	7·1	4·5	–	–	–
15			–	3·5	4·7	**11·8**	8·2	7·1	3·6	5·8	
16	–	–	–	–	5·4	8·6	**10·8**	8·7	6·2	6·2	–
17	–		–	–	4·5	6·5	7·2	**11·3**	9·4	6·6	5·5
18	–			–	2·1	5·4	7·2	10·0	**10·8**	8·5	5·3
19	–	–		–	–	5·7	5·5	9·5	9·2	**9·0**	5·5
20	–			–		5·5	3·8	6·7	8·2	8·5	5·5
21		–				3·8	2·3	5·2	6·5	7·0	**6·1**
22		–	–	–	–	3·5	2·3	3·7	4·4	5·9	5·6
23			–		–	3·1	2·6	4·1	4·6	3·1	5·5
24	–		–	–	–	2·6	2·0	3·4	2·7	3·1	3·7
25	–	–			–	–	–	3·1	2·7	2·4	3·8
26		–	–		–	–	–	2·9	2·1	1·7	3·2
27		–	–	–			–	2·1	2·1	1·3	2·0

and June. Over several years the average initial growth appears to be almost the same for corresponding year-classes. In normal summers growth is about 4–5 cm., but during the exceptionally cold summer of 1956, growth was considerably less.

The table also shows that eels of the same age-group have different growth-rates; some grow slowly, about 2 cm. in a summer, others rather fast, at least 8 cm. This results in an increase of the frequency range, which involves the gradual suppression of the mode itself; in most cases this occurs after only two summers. The growth of the 1952 group of elvers could be followed for three summers, owing to the very large number of elvers which entered the lake in that year. Further, it appears that the length-frequency curves themselves are fairly symmetrical.

Further information on growth was obtained by examination of the otoliths. In the typical eel otolith, reflected light enables us to see a dark centre surrounded by two narrow, opaque, whitish rings, which have been formed during the *Leptocephalus* stage in the Atlantic Ocean.

Opaque bands surrounding these two rings may be seen, which were formed during the period spent in fresh water. Each band is surrounded by a narrow zone, which appears dark, while the bands themselves appear white or greyish. When we compare the otoliths of eels caught over a period

Table 2

Length-frequency of male silver eels from the IJsselmeer

Length cm.	Frequency %
29	0·4
30	0·8
31	2·6
32	4·6
33	8·2
34	10·4
35	13·0
36	14·2
37	13·8
38	10·3
39	9·1
40	5·6
41	3·1
42	1·9
43	0·6

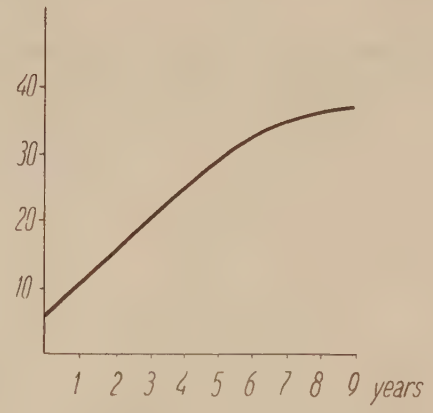

Figure 1. The average growth of male eels in the IJsselmeer.

of time, we notice that the bands lie close to the edge of the growing otolith and follow its extension during the summer, while the small dark zones are formed in winter. Hence it is obvious that each band represents a period of summer growth.

At the end of a summer, when all the eels caught with a sarran trawl had been measured, their otoliths were examined and the number of bands noted, together with the length of the eel, which gave us the ages of each centimetre group. From these data the relative length-frequencies of certain age-groups in the stock were then easily calculated and the growth deduced from the differences between them.

When these figures were compared with those deduced from the modes, it was clear that there was close agreement. This confirms the value of otoliths for determining the age of eels.

The possibility was considered of calculating the growth from the breadth of the otolith bands. The edges of these bands are not sharp, however, and estimates based on their dimensions can lead to serious errors. For this reason the method was discarded.

In general, our results are in agreement with those of Dr. B. Havinga (1945), who studied the otoliths of the older eels in the IJsselmeer. The two series of data have been combined with what is known about the normal length-distribution of silver eels, the final stage of every eel (Table 2). These data form the basis for Figure 1, which illustrates the average growth of eels, and for Table 3, which shows the gradual change in the length-frequency distribution of the 1952 group of elvers in successive years. From our figures we conclude that at least eight summers on an average must elapse before an elver in the IJsselmeer becomes a silver eel, provided that the summers are normal.

With regard to the fairly symmetrical length-frequency distribution of the male silver eels, in which a mode occurs at about 36 cm., one gets a

Table 3

Computed length-frequency distribution of eels of the 1952 elver group. The figures for the first 4 periods are deduced from otolith readings. Those for the last 4 periods are derived from the average growth (Fig. 1) and the length-frequency of silver eels (Table 2)

Length cm.	Years I	II	III	IV	V	VI	VII	VIII
8	2							
9	9							
10	28							
11	31½							
12	23	5						
13	5	11						
14	1	14	3					
15	.	17	3	.				
16	.	21	5	.				
17		13	10	½				
18		10	11	½				
19		6	12	1				
20		3	13	4				
21		1	12	8	.			
22			11	10	1			
23			9	12	3			
24			5	14	5			
25			4	14	8	1		
26			2	13	11	2	.	
27				10	13	3	1	
28				7	13½	6	2	.
29				3	13	9	3	1
30				1	11	12	5	2
31				.	8	13	8	3
32					5	13	11	5
33					3	12	12½	8
34					2	10	13	10
35					1	7	12½	13
36						5	11	14½
37						4	8	14
38						3	5	10
39						2	3	8
40						1	2	5
41							1	3
42								2
43								1

strong impression that the incidence of the silver stage occurs on attaining a certain length. This would imply, in view of the very different growth-rates, that individuals reach the silver stage at different ages. At first sight, then, the symmetry of their length-frequency distribution appears to be incomprehensible, since it must be governed by the different strengths of the various year-groups. The problem becomes clear, however, when the fact is recognized that any batch of eels of any length will, in the course of time, grow to form a group of silver eels with a length-frequency distribution

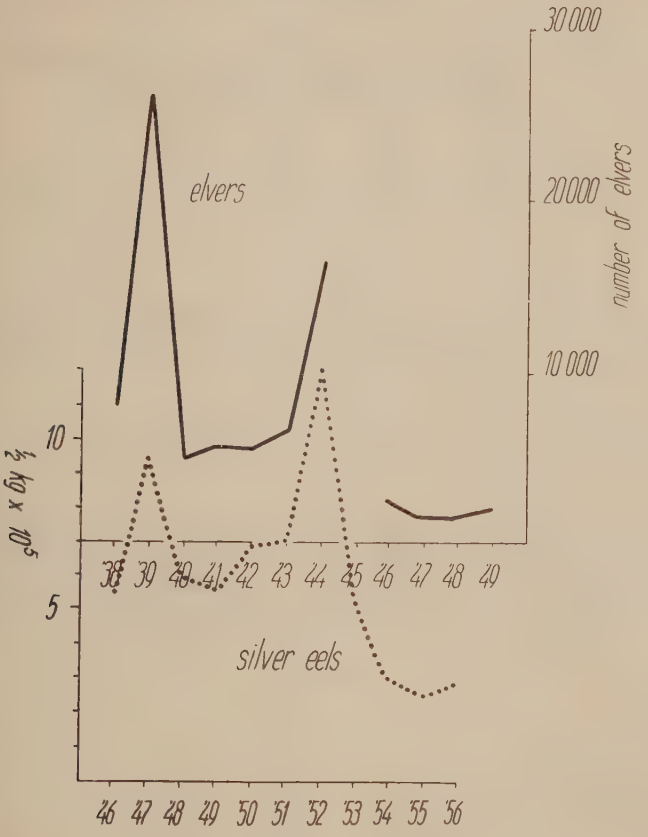

Figure 2. Comparison of elver catches with silver-eel catches 9 summers later.

which is symmetrical, although it contains eels of different ages. To investigate this point, we examined a series of otoliths from 590 silver eels caught in one night during the 1956 season. The results are shown in Table 4. Fortunately for this study, elver migration was on a small scale in all years from 1946 to 1950 (cf. Figure 2), so that the strengths of the respective silver-eel year-classes may be considered as almost equal. Table 4 shows that in the silver stage, the eels with 8 annual rings in their otoliths predominate, which again is in agreement with our previous assumption. For the sake of completeness, the length-frequency distribution of these 8-ring eels was compared with that of the whole batch, and no significant difference was found.

Next we tried to correlate the annual production of silver eels with the number of immigrant elvers. We have a rough idea of the latter quantity, because during the elver seasons from 1938 onward, elvers have been fished

Table 4

The age distribution of a batch of silver eels of normal length distribution, caught on 31. August 1956

Number of annual rings in otolith	Frequency %	Number of annual rings in otolith	Frequency %
4	0·6	9	9·1
5	9·3	10	5·2
6	17·0	11	1·7
7	19·8	12	0·7
8	36·0	13	0·4
		14	0·2

every two hours throughout the night with the same dip-net at the same spot near a sluice where the elvers congregate and try to get into the lake. The elvers caught are counted, and their numbers are taken to represent the strength of the elver migration.

No correlation was found between silver-eel catch and elver migration eight summers earlier, but there was a good correlation for an interval of nine summers (Figure 2). We must therefore conclude that, on an average, nine summers elapse between elver and silver-eel stage. As the majority of the silver-eel otoliths show only 8 bands, however, we must conclude that eels generally grow for eight summers and become silvery in the ninth; that is to say, the food taken in this summer is not used for growth, but is transformed into fat, as a store of energy for their tremendous journey back to the breeding grounds.

Summary

1) An investigation has been carried out on the growth of eels, chiefly males, in the IJsselmeer.

2) The eels show very different growth-rates; this gives rise to a broad, fairly symmetrical length-frequency distribution in every year-class (Table 3).

3) In the early stages, the average growth-rate in a normal summer is about 4 to 5 cm.; in later stages it diminishes (Figure 2).

4) The average length of the male silver eel is about 36 cm.

5) In general, a male eel grows for eight summers after the elver stage and becomes silvery in the ninth.

References

HAVINGA, B., 1954. "Rapport betreffende de Visscherij en den Vischstand op het IJsselmeer". Unpublished.

RAHN, J., 1955. "Untersuchungen über Alter und Wachstum des Aalbestandes im Sakrower See." Zeitschr. Fisch. u. d. Hilfswiss., **4**, N. F. (3/4): 235.

RASMUSSEN, C. J., 1952. "Size and age of the silver eel (*Anguilla anguilla* L.) in Esrum Lake". Rep. Danish Biol. Stat., 54: 3.

Salmon of the River Shannon (1952—1956)

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Introduction

Investigations into the biology of the Shannon salmon were initiated in 1924 (SOUTHERN, 1928). SOUTHERN dealt with the stocks from 1924 to 1926 and WENT (1938, 1940, and 1943) dealt with the material for 1927, 1928, and 1941. A routine analysis was done annually for the years 1944 to 1951 (WENT, 1946, 1950, and 1953). The present paper deals with the material collected from 1952 to 1956, inclusive.

Runs of fish

The runs of fish entering Thomond Weir (WENT, 1943) in 10-day periods from 1952 to 1956 are given in Table 1. These figures were obtained from the weekly returns, allowance having been made for the periods when the weir was not in operation.

Estimated figures for the years 1941 to 1951 may be found in previous publications (WENT, 1950 and 1953). The decrease in runs which started in 1945 continued until 1952; 1953 had the largest run of fish since 1943. There was an increase again in 1954, but 1955 had the smallest run since 1947. The year 1955, however, was abnormal from the point of view of weather. An increase in the run was again evident in 1956. Up to and including 1953 the peak of the run occurred either in the second or third 10-day period in June, but in 1951, 1954, 1955, and 1956 the peak occurred in the first 10-day period in July (Figure 1 and Table 1).

Up to 20. May each year the bulk of the fish entering the weir were spring fish and thereafter summer fish. The number of fish entering the weir up to 20. May and from 21. May to the end of the season are given in Table 2. The percentages of the 1941 run are also given for comparison. The 1941 run was pre-eminently a summer-fish run. There was an increase in the number of fish running before 20. May in the years 1952 to 1956 when compared with

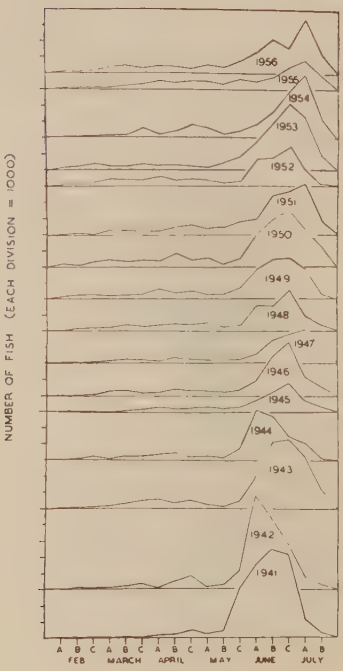

Figure 1. Showing the strengths of the run entering Thomond Weir in 10-day periods throughout the season.

A = 1st to 10th, inclusive,
B = 11th to 20th, inclusive,
C = 21st to end of month.

the 1941 figures, but there is a decrease in the number running after that date. WENT (1953) showed a similar increase in the spring-fish run from 1942 for some years.

Analysis of the stocks

Material consisting of 5,528 sets of scales was examined. The number of sets of scales examined for each year is given below.

	Year		
	1952	1953	1954
Number examined	1,150	1,558	1,294

	1955	1956	Total
Number examined	756	712	5,528

The scales of the fish were prepared for microscopical examination in the usual manner.

The smolt class and age-group for each fish were noted, but as the number of fish sampled each month was not in proportion to the catch, suitable arithmetical adjustments were made.

The proportion of each smolt class is given in Table 3. There is an increase in the proportion of the 2-year smolt class from 1952 to 1954 inclusive, but the figures for 1955 and 1956 are of the same order as those given for 1945 to 1951 (WENT, 1953). The percentage of 1-year smolts for 1955 was the highest recorded since the investigations commenced and that for the 3-year smolts was the lowest.

The distributions of the fish in the different age-groups are given in Table 4. The grilse were predominant throughout, with the small spring fish next in importance. An increase in the number of small summer fish was evident since 1954. The figure (13·3%) for 1954 was the highest yet recorded for small summer fish in the Shannon. The percentage of previous spawners was of the same order as those recorded for previous years. The large spring fish accounted for 4% or less of the stocks in the present investigations. SOUTHERN (1928) in his investigations into the stocks from 1924 to 1926 showed that the large spring fish were responsible for over 40% of the total.

The greatest run of fish occurred in the month of June each year (Table 1 and Figure 1). These fish were, in the main, grilse. Small spring fish formed the bulk of the catch up to the end of April. Except for 1954 (when the greatest percentage of the small summer fish ran in June) the major portion of the small summer fish ran in May. Table 5 gives the actual number of fish running in the periods, viz., up to and including 20. May and thereafter to

Table 1

Estimated runs of fish based on the returns from Thomond Weir

	1952	1953	1954	1955	1956
1. Jan.–10. Feb.	51	97	32	25	73
11.–20. Feb.	43	179	48	37	51
20. Feb.– end of month	129	207	59	39	70
1.–10. March	359	118	69	20	298
11.–20. –	286	110	74	124	300
21.–31. –	313	298	587	242	265
1.–10. April	533	237	220	529	364
11.–20. –	343	250	447	409	344
21.–30. –	411	172	745	481	329
1.–10. May	278	166	605	470	391
11.–20. –	192	586	239	226	335
21.–31. –	290	909	428	647	711
1.–10. June	1,783	1,803	837	514	1,233
11.–20. –	1,822	2,982	1,556	972	2,083
21.–30. –	2,399	4,132	2,860	1,448	1,673
1.–10. July	1,050	3,312	4,073	1,973	3,376
11.–19. –	260	1,873	1,114	824	1,103
Total	10,542	17,431	13,993	8,980	12,999

Table 2

Number and proportion of fish running up to and including 20. May and thereafter

Year	Number up to 20. May	Percentage relative to number in 1941	Number after 20. May	Percentage relative to number in 1941
1952	2,938	127	7,604	38
1953	2,420	105	15,011	76
1954	3,125	135	10,868	54
1955	2,602	113	6,378	31
1956	2,860	124	10,139	51

Table 3

Percentage of each smolt class in the different years

Salmon runs of	Smolt class 1	2	3
1952	15·9	81·8	2·3
1953	16·0	82·1	1·9
1954	16·4	82·4	1·2
1955	24·5	75·0	0·5
1956	21·0	77·8	1·2

19. July, and these have been compared with the numbers of spring and summer fish calculated on the basis of scale readings. Eighty per cent. and upwards of the fish running up 20. May were composed of spring fish whereas 92% and upwards of the fish running after 20. May were summer fish. Previous spawners have been omitted from these calculations, owing to the difficulty of age determination. Therefore for all practical purposes the

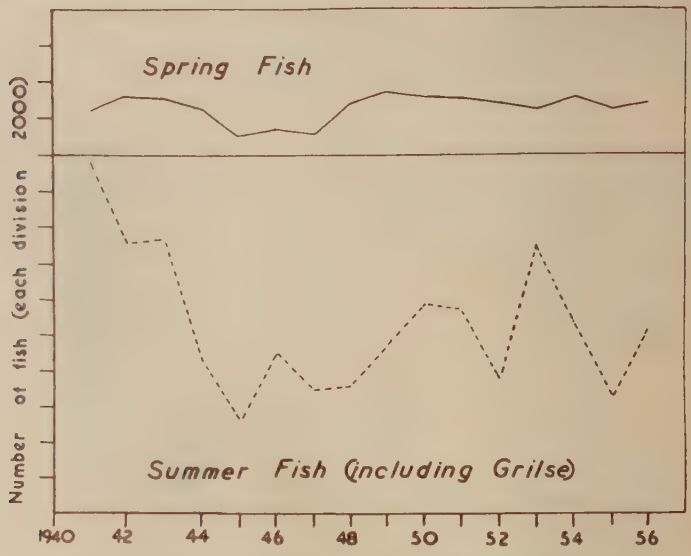

Figure 2. Numbers of spring and summer fish running in the years 1941 to 1956, inclusive.

Table 4

Percentage of each age-group in the different years

Year	Age-group in winters 1+	2	2+	3	3+	With SMs.
1952	66·7	23·7	4·4	2·3	–	2·9
1953	79·8	10·9	4·7	0·4	–	4·2
1954	61·5	22·8	13·3	0·2	0·1	2·1
1955	59·8	18·5	12·5	4·0	0·1	5·1
1956	72·2	15·9	7·5	1·4	–	3·0

Table 5

Comparison of numbers of "spring fish" and "summer fish" estimated according to the time of running and to scale examination

	1952	1953	1954	1955	1956
Numbers of fish running up to 20. May	2,938	2,420	3,125	2,602	2,860
Calculated number of *spring* fish	2,665	1,891	2,566	2,029	2,352
Number of fish running after 20. May	7,604	15,011	10,868	6,378	10,139
Calculated number of *summer* fish	7,325	14,882	10,108	6,281	10,113

fish running up to 20. May each year can be regarded as "spring fish" and those running thereafter as "summer fish". On that basis the relative abundance of spring and summer salmon is shown graphically in Figure 2 for the period 1941 to 1956, inclusive.

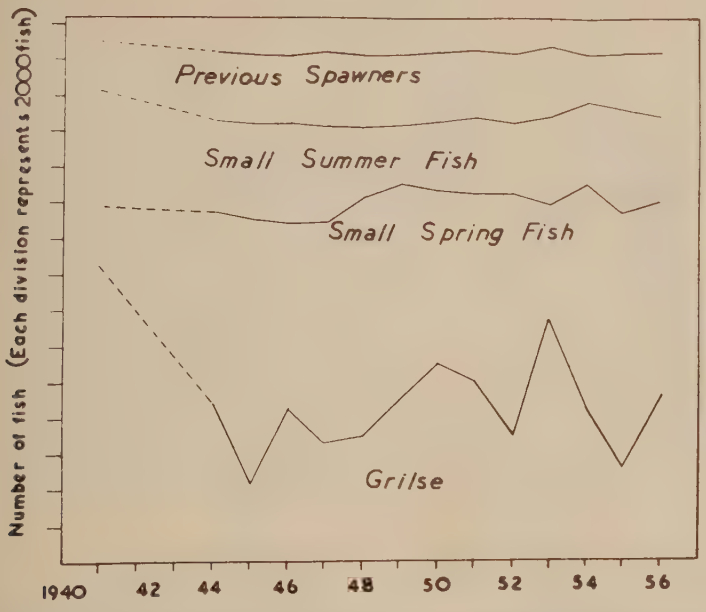

Figure 3. Fluctuations in the numbers of the four most important age-groups from 1941 to 1956 (no returns for 1942 and 1943), based on scale readings.

Table 6

Number of fish (to the nearest ten) in the different age-groups for each year

Age-group	1952	1953	1954	1955	1956
1+	7,030	13,910	8,600	5,280	9,390
2	2,500	1,900	3,190	1,670	2,070
2+	460	820	1,860	1,120	980
3	240	70	30	360	160
3+	–	–	10	90	–
With SMs	310	730	300	460	390
Total	10,540	17,430	13,990	8,980	12,990

From the actual number of fish running and the scale analysis, the number of fish in each age-group has been calculated (Table 6, Figure 3). For the sake of convenience the results for 1941 and for 1944 to 1951, inclusive, have been added to Figure 3. The year 1953 gave the highest return of grilse since 1941. In 1954 there was an increase in both the small spring and the small summer fish but a decline in the grilse run. The year 1955 had the smallest run of grilse since 1945. The run of small spring fish was also one of the lowest on record. The numbers of small summer fish for the years 1954,

Table 7

Estimated numbers of the different brood years in the catches of the different years (previous spawners omitted)

Brood Year	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	
1939....	260	10	–	–	–	–	–	–	–	–	–	–	–	incomplete
1940....	3,500	200	10	–	–	–	–	–	–	–	–	·	–	– incomplete
1941....	7,200	1,600	180	30	–	–	–	–	–	–	–		–	9,010 almost complete
1942....	550	3,980	1,700	160	–	–	–	–	–	–	–	·	·	6,390
1943....	–	440	7,570	1,740	200	10	–	–	–	–	–	–	–	9,960
1944....	–	–	970	5,020	1,890	210	–	–	–	–	–	–	–	8,090
1945....	–	–	–	1,020	6,350	2,780	180	–	–	–	–	–	–	10,330
1946....	–	–	–	–	1,210	8,630	2,390	190	31	–	–	–	–	12,451
1947....	–	–	–	–	–	1,420	10,480	2,700	220	–	–	–	–	14,820
1948....	–	–	–	–	–	–	1,520	9,050	2,120	149	–		–	12,839
1949....	–	–	–	–	–	–	–	1,740	7,325	2,493	80	–	–	11,638
1950....	–	–	–	–	·	–	–	–	540	12,077	3,850	160	–	16,141
1951....	–	–	–	–	–	–	–	–	–	1,987	8,820	2,480	120	13,407
1952....	–	·	–	–	–	–	–	–		–	940	4,580	2,360	7,880 almost complete
1953....	–	–	–	–	–	–	–	–	–	–	–	1,300	8,390	9,690 incomplete
1954....	–	–	–	–	–	–	–	–	–	–	–	–	1,730	1,730 incomplete
Total ...	11,510	6,230	10,430	7,970	9,650	13,050	14,570	13,680	10,236	16,700	13,690	8,520	12,600	

1955, and 1956 were greater than the numbers for any year of the period 1944 to 1953, inclusive.

The year of hatching can be calculated from the smolt age and the age of the adult salmon. Information relating to nine brood years from 1942 to 1951 thereby becomes available (Table 7, Figure 4). Again previous spawners have not been included, owing to the difficulty in determining their age. The figures for 1952 are almost complete. Only the number of large spring and large summer fish which would not run until 1953 remain to be added (approximately 150 fish). The return from the hatch of 1950 was the greatest, and that from 1947 was the next in importance. The brood year 1942 was the poorest.

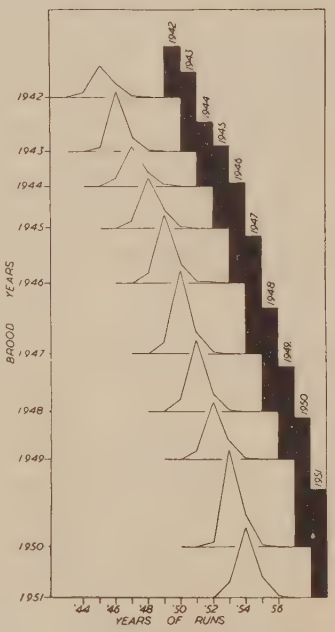

Figure 4. Showing the strengths of the different brood years and their distribution in the catches of the different years.

Summary

1. Collections of scales of salmon from 1952 to 1956 inclusive were analysed and from this the variation in the runs was determined (Tables 1 and 2, Figures 1 and 2).

2. One-year smolts comprised from 15·9% to 24·5% of the total and the 3-year smolts did not exceed 2·3% in any one year. The bulk were 2-year smolts (Table 3).

3. The grilse were the most important age-group (59·8% to 79·8% of the total) and the small spring fish were next in importance. There was an increase in the proportion of small summer fish in 1954 and 1955 (Table 4).

4. The numbers of spring and summer fish in each year's catch were calculated from scale examination, and the results were compared with the numbers obtained by consideration of the time of running (Table 5).

5. The number of fish in each age-group was calculated (Table 6, Figure 3).

6. The numbers of fish in each brood year are given in Table 7 and represented graphically in Figure 4.

Acknowledgments

I wish to thank Dr. A. E. J. Went, Inspector and Scientific Adviser, Department of Lands, Fisheries Branch, Dublin, for the interest he has shown in this work, and for his helpful suggestions in the presentation of the results. I am also indebted to the staff of the Electricity Supply Board of Ireland for the collection of the material.

References

SOUTHERN, R., 1928. "Salmon of the River Shannon, 1924, 1925 and 1926". Proc. Roy. Irish Acad., **28** B: 38–64.

WENT, Arthur E. J., 1938. "Salmon of the River Shannon". Proc. Roy. Irish Acad., **44** B: 261–322.

— 1940. "Salmon of the River Shannon". J. Dept. Agric. Dublin, **37** (2): 254–310.

— 1943. "Salmon of the River Shannon". Proc. Roy. Irish Acad., **49** B: 151–75.

— 1946. "Salmon of the River Shannon — 1944 and 1945". J. Anim. Ecol., **15** (2): 155–69.

— 1950. "Salmon of the River Shannon in 1946 and 1947". J. du Cons., Copenhague, **16** (3): 341–57.

— 1953. "Salmon of the River Shannon (1948–1951)." J. du Cons., Copenhague, **18** (3): 326–32.

Reviews

C. Cox and W. Munk. "Slopes of the sea surface deduced from photographs of sun glitter". Bull. Scripps Inst. Oceanogr., **6** (9): 401–88, pl. 10–12, 27 figs. Berkeley & Los Angeles, 1956.

The contents of this paper have already been published in an abridged form in the authors' three previous papers on this topic. One of these papers, "Statistics of the sea surface derived from sun glitter", was reviewed in **21**,3 of this journal last year. The authors have taken the opportunity in this new publication to discuss the subject at greater length, particularly the mathematical arguments. More account is also given of comparisons of their experimental results with those of other workers.

As already explained in the previous review, the principle of this new method of estimating the nature of the sea surface is to photograph the surface from an aircraft when the sun is shining. If the sea surface were absolutely flat, the sun's reflection would only be photographed when the angle subtended by the aircraft at the sea surface equals that subtended by the sun, and the photograph under these conditions would consist of a small circular white patch. These simple conditions are modified by the waves which present surfaces of various slopes to the sun's light and the photograph usually takes on the form of a diffused white pattern. The authors deduce mathematically the relations between the density distribution of the light on the photograph and the surface-wave slope distribution. This is done in Part I of the paper, called "Experimental method and observations". This section also gives the experimental results obtained which show that the "mean square slope" varies linearly with the wind speed. Part II, called "Interpretation", contains a large part of the substance of the paper reviewed previously and compares the observed slope distribution with various models of the sea surface, starting with a simple sine wave, a finite number of sine waves of different length, and a continuous spectrum with a Gaussian distribution. Finally, the results are compared with the Neumann and Darbyshire spectrum formulae. This last point was discussed at length in the previous review. In the third part, "Application", those results are applied to other oceanographical problems — in particular, those concerned with the average radiance of the sea either as viewed from above or below the surface.

The authors compare their experimental results with those of SCHOOLEY and of DUNTLEY. SCHOOLEY carried out similar measurements of glitter, but he took photographs of the surface of the River Anacostia from a bridge, using an artificial light source. His results appear to agree with the authors' for medium wind speeds (up to 10 m./s.), but not at higher wind speeds. DUNTLEY worked on Lake Winnepesaukee, New Hampshire, recording electrically the difference in immersion of pairs of thin vertical wires passing through the water surface. He obtained values two-and-a-half times higher than the authors'. These comparisons and the fact that COX and MUNK's constant in the linear law is five times that deduced from NEUMANN's spectrum formulae show that some other variables have to be considered. The most important is the fetch of the wind, and the reviewer in a recent paper*) has shown that it is possible to reconcile COX and MUNK's results with data obtained from the Atlantic Weather Ships when allowance is made for fetch.

To sum up, this new technique of slope measurement is a great contribution to this branch of oceanography and lends itself very easily to the new mathematical techniques which have been recently developed in the investigation of the statistics of the sea surface.

J. Darbyshire

J. Jarke. "Der Boden der südlichen Nordsee. Eine neue Bodenkarte der südlichen Nordsee". Deutsche Hydrogr. Zeitschr., **9** (1): 1–9, Taf. 1. Hamburg, 1956.

Twenty-five years ago, much the most of what was known about the bottom lithology of the southern North Sea was contained in the well known 1923 report by BORLEY and in PRATJE's large monograph on the sediments of the German Bight, published in 1931. In 1937 PRATJE took over responsibility for the subject of marine geology in the *Deutsche Seewarte*, and had, from 1946 until his death six years later, the same charge within the German Hydrographic Institute, then newly established in Hamburg.

An important part of his task was to work up the very extensive German collection of sea-bottom samples so that charts portraying type distributions could be published from the presses of that Institute. During World War II an atlas of bottom sediments of the North Sea had appeared as one of a series of thirteen, and after that war, PRATJE published charts portraying the bottom lithology of the White Sea and of the English Channel. At and before that time, a very useful source of information on what official British hydrographers customarily call "Nature of Bottom" was the official German fisheries chart of the North Sea, drawn to the scale of 1:900,000 and issued in two sheets. That chart, in addition to delineating foul ground for the benefit of trawlermen, carried two overprintings in colour to depict a broad division of bottom types. PRATJE had the ambition to do much better, and when his Institute became possessed of seagoing facilities, thanks to its aquirement of the survey and research vessel "Gauss", he lost no opportunity to gather bottom samples far and wide over the North Sea. He devoted

*) See Q. J. R. Met. Soc. **82**: 461, 1956.

great effort to "filling in the gaps" and, to that end, he designed and perfected an improved version of the American underway sampler, the "Scoopfish". His instrument was so successful as to be adopted by at least one American oceanographical organization. PRATJE amassed a vast amount of new information and worked on it assiduously in his shore laboratory, producing, amongst other things, several small chartlets delineating nature of bottom for inclusion in the official German Sailing Directions.

In work at sea PRATJE collaborated fruitfully with his colleague F. SCHÜLER, an expert in electronics and on echo-sounding gear. Inferences as to nature of bottom deduced acoustically were compared with and checked against actual samples collected under way. The information grew amain and when PRATJE died in 1952, the work came under the charge of JARKE, whose publication is now under notice.

For some years it had been an aim of JARKE and his colleague Th. STOCKS, the eminent expert on bathymetry, to produce a chart of the southern North Sea which should unite in the one presentation a delineation of bottom types and of depth contours.

The chart under notice, produced to the scale of 1:1 million and utilizing the copious new depth data gathered during many cruises of the "Gauss" and other German ships is a big step in that direction, though without depth contours at present. Fourteen descriptions are used for the types of bottom delineated by that number of colour combinations, and six symbols are used additionally to denote local occurrences of rock, stones, gravel, the two latter together, peat, and swamp. Not surprisingly, JARKE has plenty of difficulties, but we may rightly be grateful to him for producing a chart of great interest and usefulness. It is naturally a very great advance on any pre-existing charted portrayal of the nature of the bottom of the southern North Sea, and persons who (like the reviewer) have a particular interest in fisheries research will give it a warm welcome. Studies of such benthic communities as find congenial conditions on this or that type of ground will be much aided by the chart, which should also have a special value to those whose work directs attention to the distribution of bottom-fixed fish ova.

Features which immediately strike the eye, thanks to the efficient and pleasing use of colour, are the 60-mile long and 15-mile wide belt of very fine sand stretching south from the Clay Deep, the patch of the same material in the Outer Silver Pit, and the belt of similar patches trending S.E.-N.W. and leading off from the Elbe estuary. Gravel is seen to occur plentifully off the English coast from Spurn northwards, and coarse sand shows up clearly in the deeps of the Southern Bight. Overwhelmingly dominant in area on the coloured chart are the greens which depict the distribution of the various gradings of sand. There would be little point in discussing the author's gradings and no sense of proportion in picking out for attention details of a chart which would require too much space for full comment; that being so, it suffices to express admiration of a work which is of great usefulness, of high artistic merit, and which embodies so much information industriously gathered and painstakingly presented.

J. N. Carruthers

N. S. Jones. "Cumacea of the Benguela Current". Discovery Rep., **27**: 278–92, 7 figs. Cambridge, 1955.

Les Cumacés décrits dans ce travail ne concernent que cinq espèces dont deux espèces nouvelles, *Diastylis rufescens* et *Iphinoë fagei*; mais le nombre des individus récoltés est considérable, il s'élève environ à 7700 femelles, mâles, et juvéniles. Les captures ont été faites, à des profondeurs de 64 à 204 m., en partie au cours de pêches verticales, à l'aide d'un filet à plancton et, plus rarement, au cours de pêches horizontales. A toutes les stations où la teneur en 0_2 sur le fond a été déterminée, elle s'est montrée très faible.

On sait que bon nombre d'espèces, notamment dans les genres *Bodotria*, *Iphinoë*, et *Diastylis* ici représentés et qui vivent normalement sur le fond, opèrent une migration verticale nycthémérale qui a pour résultat de les grouper en très grand nombre la nuit dans le plancton. Et la question est de savoir si les riches captures de la "Discovery" sont dues seulement à ce phénomène, ou au fait que, sur le fond même, la teneur en 0_2 serait trop faible pour y permettre le séjour normal des individus qui seraient ainsi devenus en quelque sorte pélagiques permanents.

Il est a noter que les pêches de jour ont donné seulement 1 mâle, 8 femelles, et 17 jeunes d'*Iphinoë fagei* et 20 mâles, 20 femelles et 2 jeunes d'*Upselaspis caparti* (Fage), ce qui représente un total bien faible par rapport aux 7700 individus capturés en tout.

Il y a donc tout lieu de penser que l'on assiste bien là à une migration verticale nocturne des reproducteurs, à la formation d'essaims temporaires analogues à ceux que notamment Fage (1933) et Forsman (1938) ont signalés. Quant à savoir si durant le jour, les individus regagnent le fond, il suffirait de l'emploi d'une drague spéciale pour en avoir la certitude.

C'est avec raison que l'auteur a placé dans le genre *Upselaspis*, le *Cyclapoides caparti* prédédemment rencontré dans le Walvis Bay.

L. Fage

J. E. Morton. "The pelagic mollusca of the Benguela Current. Pt. 1. First survey, R. R. S. 'William Scoresby', March 1950". Discovery Rep., **27**: 163–200, 17 figs. Cambridge, 1954.

Si l'on en juge d'après les récoltes du "W. Scoresby", le courant du Benguela n'offre guère de diversité en ce qui concerne les Mollusques pélagiques. En effet, outre quelques rares formes larvaires ou post-larvaires, la liste fournie indique seulement *Ianthina ianthina*, *I. globosa*, *Atlanta peroni*, *Limacina inflata*, *L. bulimoides*, *Diacria trispinosa*, *Euclio pyramidata*, *Cavolinia inflexa*, *Cymbulia peroni*, *Thliptodon diaphanus* et *Pneumodermopsis paucidens*.

De toutes ces formes, les plus nombreuses sont les *Limacina* dont le maximum d'abondance se situe de jour vers 50–100 m. et de nuit vers 100–250 m. En réalité, au dessous de 150 m. de jour et de 350 m. de nuit et jusqu'à 750 ou 1000 m., le nombre des individus est faible. De plus, un second maximum s'observe de nuit vers la surface. Y a-t-il effectivement des migrations? En ce cas, elles ne seraient probablement effectuées que par les plus grands individus.

On a de bonnes raisons de penser que les *Limacina* sont dévorées par les Gymnosomes et à cet égard la répartition en profondeur de *Pneumodermopsis paucidens* apparaît significative, car elle coïncide avec celle de *Limacina bulimoides*.

L'étude minutieuse du tractus génital de *L. bulimoides*, qui se présente comme hermaphrodite protandrique et se trouve de ce fait être comparable aux Ellobiidae est une heureuse découverte qui a permis à MORTON de fournir une interprétation de l'évolution de la sexualité chez l'ensemble des Gastropodes.

Six stades sexuels successifs peuvent être reconnus. L'évolution de la gonade se déroule dans les trois premiers, juste avant l'apparition du pénis et de la prostate tubuleuse. Au cours du quatrième stade, lorsque ces deux organes sont bien développés apparaissent les conduits femelles sans leurs annexes glandulaires. Les cinquième et sixième stades correspondent aux phases fonctionnelles respectivement mâle et femelle.

Le pénis fort compliqué ainsi que la prostate tubuleuse apparaissent par leur structure et leur situation comme des organes primitifs.

Dans les *L. bulimoides* du Benguela il existe une saison de ponte autumnale et il semblerait qu'il en soit de même au printemps; mais il se pourrait que la période de reproduction s'étende sur toute l'année. La succession des phases sexuelles apparaît ici plus étalée dans le temps que dans les mers froides comme le montre la comparaison avec *L. retroversa*. En effet, dans l'Atlantique Nord la différenciation sexuelle débute en hiver (HSIAO) et les "mâles purs" apparaissent en mars. La prédominance de ces derniers fait ensuite place à la prédominance des femelles; puis la ponte débute en fin avril. Dans les eaux anglaises par contre, les oeufs mûrissent durant la plus grande partie de l'année, mais il y a un maximum en été et chaque individu pourrait pondre plusieurs fois. On peut en tous cas supposer que dans les Limacinidae comme dans l'ensemble des Opisthobranches l'évolution s'est faite à partir d'une protandrie complète en direction de l'hermaphrodisme simultané.

L'hypothèse que MORTON formule au sujet de l'évolution de la sexualité chez les Gastropodes est très intéressante. Le tronc commun aux Prosobranches, aux Opisthobranches, et aux Pulmonés, situé probablement au niveau des Archaeogastropodes comprenait des formes protandriques. Une tendance à la séparation des sexes dans divers individus s'est alors manifestée et à de rares exceptions près cette séparation s'est trouvée réalisée dans la majeure partie des Prosobranches actuels. Mais déjà les Mesogastropodes s'avèrent trop spécialisés pour être à l'origine des Opisthobranches ou des Pulmonés. Ayant conservé l'hermaphrodisme, ces deux sous-classes ont pu s'individualiser à partir d'un rameau d'Archaeogastropodes à un niveau plus élevé que celui qui a fourni les Mesogastropodes. Chacune d'elles débute comme protandrique et montre une évolution en direction de l'hermaphrodisme simultané, les oeufs et les spermatozoïdes étant produits côte à côte.

A. Franc

A. C. Hardy. "The Open Sea — Its Natural History: The World of Plankton". The New Naturalist. A Survey of British Natural History. 335 + XV pp., 103 figs., 24 pl. Collins, London, 1956.

Both the editors' and the author's prefaces describe this book as having been written for the enlightened amateur naturalist, to encourage him to investigate the world of plankton himself, and also to serve as a guide for university students beginning studies in marine biology; the intention has not been to present a handbook in planktology. On cursory inspection of the volume, attention is immediately drawn to the beautiful illustrations, which include 142 water-colour sketches done by the author and 67 black-and-white photographs by the famous photographer of marine organisms, Dr. Douglas WILSON; these illustrations are eminently suited to arousing the interest of naturalists, young or old. The text is written in a direct, personal style, which accords well with the purpose of the book.

In most chapters the broad scope and the first-hand knowledge of the subjects treated have a stimulating effect; this is especially welcome in those cases in which the author taxes the patience of the reader rather heavily by lengthy and rather intricate discussions and detailed descriptions. The enthusiasm of the author does not leave the reader unaffected, whether he is aroused by the beauty of the objects described or by the wealth of the problems still to be solved.

The title of the book is somewhat misleading. Of the 315 pages, only 30 pages are devoted primarily to plant plankton; the remainder treat of the zooplankton and other animals. Since the chapters on "Plants of the Plankton" and "On Seasons of the Sea" are in many ways not the most satisfactory, it might have been an advantage if they had been omitted and the book given the more appropriate title, "The World of Zooplankton".

The introductory chapters include historical notes on British marine biological research, which will be read with great interest by professional planktologists. There follow chapters on little jelly-fish and lesser forms of life, siphonophores and the larger jelly-fish, more animals of the plankton (but not the crustaceans), the planktonic Crustacea, pelagic larval forms, the puzzle of vertical migration, life in the depths, phosphorescence and photophores, squids, cuttlefish and kin, and a concluding chapter on plankton and fisheries. Through these many facets, the author provides an extensive and stimulating outlook on the state of present knowledge and on the problems yet unsolved, and brings together from many sources, often not easily accessible, pieces of the puzzles encountered in every field of planktology.

It is of special interest to find here an account of the researches in many fields which the author himself started and to have his own appreciation of the new results accumulated by both his and his pupils' subsequent studies. As is the natural course of science, these have led to many revisions of the original theories. All through the book the author demonstrates his open mind and his receptivity of new ideas, and frequently refers to hypotheses which run contrary to generally adopted views.

Non-British readers of *Journal du Conseil* should note the subtitle of the series, "A survey of British natural history"; otherwise, on reading Professor

HARDY's book, they might feel that investigations of general interest have been unduly disregarded.

Although the book may not be so well suited for university teaching outside Great Britain, it undoubtedly makes stimulating reading, not only for amateurs but also for professional marine biologists, since it presents so many details which are useful in teaching and because it provokes fresh consideration of many essential problems in marine biology.

Trygve Braarud

M. H. A. Keenleyside. "Some aspects of the schooling behaviour of fish". Behaviour, **8** (2–3): 183–248, 18 figs. Leiden, 1955.

The schooling behaviour of fish is an interesting phenomenon that for long has puzzled many observers. Most have been resigned to their puzzlement; but a few bold persons have attempted to understand and explain schooling in fish — or at least some aspects of it. Such attempts, more often than not, have posed more problems than they have resolved.

KEENLEYSIDE rightly and necessarily opens his paper with a brief résumé of previous work on fish schooling, with special reference to attempts to define a school or shoal of fish. Not unexpectedly, he is dissatisfied with all the previous definitions that he has been able to find and provides a new one of his own — which is quite as unsatisfactory as all the others. According to KEENLEYSIDE, "the school will be considered an aggregation formed when one fish reacts to one or more other fish by staying near them". Fish congregated in a limited area because each animal responds similarly to a common external stimulus do not constitute a school. Thus solitary fish, such as pike, concentrated in one part of a lake because a steep temperature gradient prevents their occupying a larger area, are not to be regarded as a school but simply as an "aggregation" of fish. Such distinctions are merely academic quibbles and are largely meaningless. How, in the sea for example, is anyone to distinguish one kind of grouping from the other? In so far as the reviewer is concerned, any close concentration of one species of fish in its natural habitat is a school or shoal of those fish, no matter what may be the cause or causes of its formation. It follows, therefore, that he believes that many factors, both internal and external, can be responsible for schooling in fish whether the school be large or small, temporary or semi-permanent.

Moreover, all investigators of schooling behaviour in fish known to the reviewer, including KEENLEYSIDE, appear to think almost, if not entirely, in terms of pelagic fish. They do not tell us, for example, what name we are to give to a school of pelagic fish when, as sometimes happens, it goes to ground and spreads out compactly, but only one fish deep, on the bottom. Seldom, if ever, is it still referred to as a school or shoal. Therefore, even granting that KEENLEYSIDE's definition holds good in the pelagic phase — i. e., that one fish reacts to one or more other fish by staying near them — is it to be understood that such awareness of other fishes of its kind disappears immediately an individual fish touches the bed of the sea or of a lake? And what of wholly demersal fish? In the vicinity of Plymouth (England) there

is an area where *Raia clavata* congregates in compact herds, consisting almost entirely of one sex, on the sea floor in spring. These groups or aggregations of bottom fish are seldom referred to as schools or shoals. If, however, those same concentrations of rays were to appear at or near the surface of the sea, or even well clear of the bottom, they would undoubtedly be generally regarded as schools or shoals of ray, even though only one fish deep. The same could be said of other demersal fishes in other places and at other times.

To identify and define the various factors responsible for schooling behaviour in fishes is undoubtedly difficult and there are many pitfalls for the unwary. This, of course, is unimportant, provided always that the difficulties are squarely faced. This KEENLEYSIDE does not do, and therefore fails to avoid pitfalls or even to realize when he has stumbled into them. The fishes with which he worked included the three-spined stickleback, *Gasterosteus aculeatus* L., the rudd, *Scardinius erythrophthalamus* (L.), and *Pristella riddlei* (MEEK). Observations and experiments were made mainly with small numbers of fish in specially designed aquarium tanks; but certain observations on rudd were made in a shallow outdoor pond. One observation to which particular attention is drawn is that in this pond young rudd, when alarmed, formed a dense, uniformly oriented *school* one or two metres off shore and then swam back and forth parallel to the shore. If not further disturbed the fish gradually returned to shallower water where they had been before. The reason for this return, says KEENLEYSIDE, is not clear "but a preference for warmer water may be the most important factor." If this indeed were so, the actions of the fish under observation surely were, in large part, common responses to external stimuli which KEENLEYSIDE himself dismisses at the outset as not being schooling behaviour at all. This distinction, however, he fails to make when confronted with it in the field. Such inconsistencies are all too common in behaviour studies of animals.

It is a moot point whether groups of fish in aquarium tanks are schools or not; the most that one can be sure of is that they are assemblages of fish fortunate or unfortunate enough to be caught alive (or successfully reared) and cooped up together in tanks. Any observations on or experiments made with such fish must, therefore, be used with the utmost caution when basing conclusions upon them. This is especially so because, as LORENZ has pointed out in *King Solomon's Ring*, two aquaria separated from each other by only a few inches have individual characters just as sharply defined as two lakes many miles apart. Nevertheless, KEENLEYSIDE's observations and experiments, both in aquaria and in the field, lead him to conclude with reasonable certainty that sight plays a not unimportant part in some types of schooling behaviour. This, however, is by no means a new discovery. He suspects, but has been unable to prove, that "specific chemical, tactile, auditory, lateral line or even electrical stimulation from nearby fish" may help to keep a group together. In short, this whole paper serves to emphasize how much remains unknown about schooling behaviour in fish.

G. A. Steven

G. H. Nall. "Movements of salmon and sea trout chiefly kelts, and of brown trout tagged in the Tweed between January and May, 1937 and 1938." Scottish Home Dept., Freshw. and Salmon Fish. Res., 10: 1–19, 1 fig. Edinburgh, 1955.

This paper is the last written by the late G. H. NALL. It describes the results of tagging experiments conducted in 1937 and 1938 in efforts to add to the existing knowledge of the salmon and sea trout of the Tweed. The number of salmon tagged was small (153), most of them (115) kelts. The majority of the kelts were small spring and summer fish. There was evidence that in the early spring the clean fish "by no means invariably move steadily upstream", and they may move up and downstream in the tidal waters.

Twenty-one kelts were recaptured before they returned to the sea, a few of them several times. The records of recaptures indicate that the downstream movement of the kelts may be broken from time to time by upstream movements. Although the majority of the kelts regained the sea early in the year some remained in the river until May, apparently hesitating to enter the open sea.

The material relating to sea trout was much more extensive than that for the salmon. Altogether 883 sea trout, of which 701 were kelts, were tagged. Nearly 39% of the tagged sea trout were recaptured, some being recaptured up to six times. Most of the recaptures were made soon after tagging and before the fish regained the sea. Only 37 fish had regained the sea and had made new growth. Of these about 70% were recaptured on their return to the Tweed and the remaining 30% were taken outside the Tweed.

Of the sea trout retaken outside the Tweed two were taken in the Forth and four in the Tay to the north of the Tweed, and one in the Coquet, one at Blyth near North Shields, one off each of the Yorkshire and Norfolk coasts, and one off the Dutch coast. As in the case of the salmon there is evidence that the sea trout moved up and downstream in the tidal waters before regaining the sea. One cannot do better than quote just one sentence from the paper, which sums up the point. NALL wrote "The impression we receive is of a restless population, constantly on the move, now up, now down, yet unwilling to leave the river till conditions are favourable for a change from tidal water to the open sea." Some sea trout kelts after regaining the tidal waters returned to fresh water; some travelled very long distances within a few days. These results are very puzzling, as NALL points out in a crisp sentence, as follows. He wrote "One of the most puzzling problems is why at this time of year a clean sea trout tagged above tidal reach, which is not a member of the early spring run and presumably is a descending not an ascending fish, should move upstream instead of down".

A small number of brown trout were tagged, but the results are really of little value.

A. E. J. Went

K. Larsen. "Fish population analyses in some small Danish trout streams by means of D. C. electro-fishing (with special reference to the population of trout (*Salmo trutta* L.)." Medd. Danmarks Fisk.- og Havunders., N. S., **1** (10): 1–69, 38 figs. + 8 pl. København, 1955.

In recent years electrical methods have been used to carry out surveys of the stocks of fish in small rivers and streams. The author of this paper outlines older methods using various forms of fishing gear including nets, rods, etc., and poisoning, and he points out their inherent defects. He then describes in detail the apparatus and methods used in this investigation. Altogether 35 stations on 26 small streams (none more than 4·2 m. wide) on 26 rivers, 20 in Jutland, 3 in Seeland, and 3 in Bornholm, were fished by means of two pieces of D. C. electrical-fishing apparatus with voltage differences of 130–270 and 220–240, respectively. The author claims that these electrical methods are highly effective (from 80 to 100%) and have none of the disadvantages mentioned earlier.

Altogether 16 species of fish were recorded. At least 3 species, rainbow and American brook trout, and crucian carp, had found their way into the stream accidentally, the trout as escapes from trout farms. The young salmon observed originated from liberations of fry. Trout were found in all the streams and in three they were the only species present. The actual species present depended on the type of stream and in particular the depth and strength of the current. The freshwater eel was found in 25 localities and the author suggests that its occurrence in these small trout streams is dependent upon summer temperature and the renewal of water, a high summer temperature and a slow current favouring the eels where access by elvers is readily available. Two species of sticklebacks were also present to some extent in some of these streams and together they constituted about 6·7% of the total number of fish present. Thirteen other species of fish played a subordinate part in these Danish trout streams.

Populations up to 432 fish (412 trout, 12 salmon, and 8 eels) per 100 sq. m. were recorded in one locality and the smallest density was only 4·9 fish per 100 sq. m. Generally the trout were small, except where mature fish, ascending presumably for spawning, were taken. The small size of the fish was due to their young age and not to slow growth-rate.

The author discussed at length the importance of these trout to Danish fishermen and stressed the necessity for care in designing sewage schemes, dams for power, etc. to ensure that living conditions for these fish are not adversely affected.

One very important conclusion reached is that in many of these streams it is undesirable to plant trout fry, as they are probably carrying as large a stock of fish as they can support naturally. The author points out the necessity for work of this kind on a much larger scale but suggests that until this is done liberations of trout fry should be more or less limited to those waters which cannot be reached by spawning trout.

The author is to be congratulated on his energy and clear exposition on what is a difficult subject to describe. The paper is well illustrated by line drawings and photographs and contains, apart from the details already

mentioned, much interesting information on the fauna and flora of these small Danish trout streams, which are so important in the general economy of trout fishing in Denmark. The photographs emphasize that no small stream should be neglected in this type of work because each one has a contribution, albeit small, to make to the general well-being of the Danish trout fisheries.

A. E. J. Went

F. A. Brown, Jr., M. F. Bennett, H. M. Webb, and C. L. Ralph. "Persistent daily, monthly, and 27-day cycles of activity in the oyster and quahog." J. Exp. Zool., **131** (2): 235–62, 6 figs. Philadelphia, Pa., 1956.

Analysis of the activities of oysters and quahogs as indicated by the periods for which their shells are open has revealed persistent rhythms. Such rhythms, not readily apparent in individuals, nevertheless show clearly when the activities of several specimens, maintained under controlled conditions of light and temperature, are compared.

The authors have described a daily cycle of activity in both species. They show a low degree of activity in the early morning, which is much increased during the rest of the day. Maxima tend to occur in the late morning and late afternoon. The fact that specimens collected from widely spaced sources all behaved in essentially the same way under controlled conditions convinced the authors that the rhythm was not an impressed tidal one, as the patterns did not differ, in time, one from another.

Attempts made to correlate the forms of the mean daily cycles in terms of responses to changes of barometric pressure showed that there was only a general relationship between pressure and activity. It would appear that there is no straightforward passive response to changing pressures, and where the rate of change varies, there is, on occasion, an apparent inverse relationship for which there is no adequate explanation.

More detailed analysis of the behaviour showed not only a persistent daily rhythm but also a monthly one with a high degree of correlation between the two species.

In addition a clearly defined 27-day cycle in the activity pattern is shown in all four different series of month-long experiments with oysters and in two out of three series with quahogs.

It is suggested that the animals are responding to some external factor which is in itself related to pressure change. As barometric pressures change with both primary lunar and primary solar cycles, it is to be expected that pressure sensitivity would result in rhythmic behaviour in phase with both these factors. The authors further suggest that the 27-day cycle is related to the period of rotation of the sun on its axis and that the influencing factor is some form of high energy radiation, such as cosmic radiation, which may be playing a triggering role in setting off a chain of responses. These in turn are modified by concurrent pressure changes. However, there is no suggestion as to how the animal's sensitivity to these factors is achieved.

G. D. Waugh

Current Bibliography

Prepared by the Editor with the Assistance of Mr. A. R. Margetts

Note. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

1) General Oceanography and Fisheries

1) a Expeditions

Anon. "Campañas del 'Xauen' en la costa noroeste de España en 1949 y 1950. Registro de operaciones". Bol. Inst. Español Oceanogr., **71**. Madrid, 1955.

Anon. "Royal research ship 'Shackleton'". Polar Rec., **8** (53): 180. Cambridge, 1956.

Anon. "British fisheries research vessel 'Explorer'". Polar Rec., **8** (53): 180. Cambridge, 1956.

Capurro, L. R. A. "Expedición Argentina al Mar de Weddell". Argentine Min. Mar., 186 pp. Buenos Aires, 1955.

Grainger, E. H., & Dunbar, M. J. "Station list of the 'Calanus' expeditions, 1953–4." J. Fish. Res. Board Canada, **13** (1): 41–5. Ottawa, 1956.

Lee, A. J. "British fishery research in the Barents Sea". Polar Rec., **8** (53): 109–17. Cambridge, 1956.

Martin, J. "Compte rendu sommaire de travaux océanographiques français récents dans l'Océan Indien et dans l'Océan Austral". Bull. d'Inform., (COEC), **8** (7): 299–305. Paris, 1956.

McGary, J. W., Jones, E. C., & Austin, T. S. "Mid-Pacific oceanography, Part IX, Operation Norpac." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., **168**. Washington, 1956.

Motoda, S., & Fujii, T. "Report from the 'Oshoro Maru' on oceanographic and biological investigations in the Bering Sea and northern North Pacific in the summer of 1955. In programme of investigations and records of eye observations of seabirds and marine animals." Bull. Fac. Fish. Hokkaido Univ., **6** (4): 280–97. Hakodate, 1956.

Sætersdal, G. "Rapport om tokt med 'G. O. Sars' til Barentshavet 14/3–26/4 1956." Fiskets Gang, 19: 75–7. Bergen, 1956.

1) c Institutes

ANON. "84th annual report for 1953–1954." Canadian Dept. Fish. Ottawa, 1955.

ANON. "East African Marine Fisheries Research Organization annual report 1954–1955". East African High Commission. Nairobi, 1955.

ANON. "Government of India Central Marine Fisheries Research Station, Mandapam Camp. Annual report of the Chief Research Officer for the year ending 31st March 1954." Indian J. Fish., **2** (2): 373–404. Bangalore, 1955.

ANON. "Central Inland Fisheries Research Station, Calcutta. Annual report for the year 1953." Indian J. Fish., **2** (2): 405–20. Bangalore, 1955.

ANON. "Aperçu sur les recherches Japonaises en matière d'océanographie physique d'après un rapport du Dr. G. E. R. DEACON, directeur du National Institute of Oceanography". Bull. d'Inform. (COEC), **8** (7): 296–8. Paris, 1956.

ANON. "Annual report of the National Oceanographic Council, 1955–56". C. U. P., Cambridge, 1956.

ANON. "Annual report 1955 and review of Institute's activities 1945–1955". Inst. Seaweed Res., Inveresk. Midlothian, 1956.

ANON. "21st annual report of the Herring Industry Board for the year ended 31st December, 1955." London, 1956.

ANON. "Eighth annual report of the Pacific Marine Fisheries Commission for the year 1955". Pacific Mar. Fish. Comm. Portland, 1956.

ANON. "Annual report for 1954–55." Scottish Mar. Biol. Assoc., Collect. Repr. 1955, 208. Glasgow, 1956.

BARNES, H. "Underwater television and research in marine biology, bottom topography and geology. Part 2. Experience with the equipment." Deutsche Hydrogr. Zeitschr., **8** (6): 213–36. Hamburg, 1955.

PETIT, G. "Rapport sur le fonctionnement du Laboratoire Arago en 1955." Vie et Milieu, **6** (4): 551–63. Paris, 1956.

PETIT, G., & TREGOUBOFF, G. "Rapport sur le fonctionnement de la Station Zoologique de Villefranche en 1955." Vie et Milieu, **6** (4): 564–8. Paris, 1956.

PICOTTI, M., & POLLI, S. "Annuario 1955". Pubbl. Ist. Speriment. Talassogr. Trieste, 330. Trieste, 1956.

YANEZ, P. "La biologia pesquera, actividad preferente de las estaciones de biologia marina Latino-Americanas". Rev. Biol. Mar., **6**: 21–8. Valparaiso, 1956.

1) d General Phenomena

ANON. "Animal sounds in the sea." Nature, **178** (4520): 1117–18. London, 1956.

MACHLUP, S., & HERSEY, J. B. "Analysis of sound-scattering observations from non-uniform distributions of scatterers in the ocean". Deep-Sea Res., **3** (1): 1–22. London & New York, 1955.

UDA, M. "Researches on the fisheries grounds in relation to the scattering layer of supersonic wave. Introductory report". J. Tokyo Univ. Fish., **42** (2): 103–11. Tokyo, 1956.

1) e General Apparatus

MOSBY, H. "Note on wire angle in oceanography". J. Mar. Res., **14** (3): 259–60. New Haven, Conn., 1955.

PICCARD, A. "In balloon and bathyscaphe". Cassell & Co. Ltd. London, 1956.

1) f General Textbooks

PANZARINI, R. N. "Consideraciónes generales para la organización de las actividades oceanograficas." Rev. Biol. Mar., **5**: 68–83. Valparaiso, 1955.

2) Physical Oceanography

2) a Practical Aspects

ANON. "Oceanographic field observations in the Arctic near Point Barrow, Alaska". Rep. US Navy Electronics Lab., **189**. San Diego, 1950.

ANON. "Beobachtungen auf den deutschen Feuerschiffen der Nord- und Ostsee im Jahre 1954". Meereskundl. Beobacht. Ergebn., **7**. Hamburg, 1955.

Anon. "Observations hydrologiques des bâtiments de la Marine Nationale. A. 'Ingénieur Hydrographe Nicolas', décembre 1955; B. Flotteurs témoins de courants." Bull. d'Inform. (COEC), **8** (3): 140–1. Paris, 1956.

Anon. "Nautisk-Meteorologisk Årbog 1955." Danske Meteorol. Inst., Charlottenlund, 1956.

Anon. "Observations of sea water, temperature and salinity on the Pacific coast of Canada". Fish. Res. Board Canada, **15**. Nanaimo, B. C., 1956.

Anon. "Meteorologische en oceanografische waarnemingen verricht aan boord van nederlandse lichtschepen in de Nordzee. Jaargang 6 – 1954". Kon. Nederlands Meteorol. Inst. De Bilt, 1956.

Anon. "Research vessel 'Ernest Holt'. Hydrographical observations 1950". Min. Agric. Fish. Food. London, 1956.

Anon. "Oceanographic observations of the Pacific, 1949". 368 pp., Univ. California Press, Berkeley, Cal., 1956.

Deacon, G. E. R. "Marine physics". Proc. Inst. Civil Engin., Pt. 1, **5**: 661–76. London, 1956.

Grainger, E. H., & Dunbar, M. J. "Station list of the 'Calanus' expeditions, 1953–4." J. Fish. Res. Board Canada, **13** (1): 41–5. Ottawa, 1956.

Karlovac, O. "Station list of the M. V. 'Hvar' fishery-biological cruises 1948–1949." Izvjesca Rep., Inst. Oceanogr. Ribarst., **1** (3). Split, 1956.

Model, F. "Isotope und Ozeanographie." Deutsche Hydrogr. Zeitschr., **8** (5): 203–6. Hamburg, 1955.

Picotti, M. "Unita di misura nella chimica talassografica". Pubbl. Ist. Speriment. Talassogr. Trieste, **321**. Trieste, 1955.

Uda, M., Watanabe, N., & Ishino, M. "General results of the oceanographic surveys (1952–1955) on the fishing grounds in relation to the scattering layer". J. Tokyo Univ. Fish., **42** (2): 169–207. Tokyo, 1956.

2) b General Features of Oceans and Seas

Anon. "Natural history of coral atolls." Nature, **177** (4509): 607. London, 1956.

2) c Submarine Topography

Anon. "Cosmic spherules in deep sea sediments." Science, **123** (3194): 430. Lancaster, Pa., 1956.

Berthois, L., Chatelin, P., & Marcou, A. "Influence de la salinité et de la température sur la vitesse de sédimentation dans les eaux de l'estuaire de la Loire". C. R. Acad. Sci., **237**: 465. Paris, 1953.

Bourcart, J. "Recherches sur le plateau continental de Banyuls-sur-Mer." Vie et Milieu, **6** (4): 435–524. Paris, 1956.

Buffington, E. C., Carsola, A. J., & Dietz, R. S. "Oceanographic cruise to the Bering and Chukchi Seas, summer 1949. Part 1. Sea floor studies". Rep. U.S. Navy Electronics Lab., **204**. San Diego, 1950.

Ericson, D. B., & Wollin, G. "Correlation of six cores from the equatorial Atlantic and the Caribbean." Deep-Sea Res., **3**: 104–25. London & New York, 1956.

Ginsburg, R. N., & Lloyd, R. M. "A manual piston coring device for use in shallow water." J. Sediment. Petrol., **26** (1): 64–6. Tulsa, Okla., 1956.

Gómez de Llareña, J. "Algunos datos sobre los sedimentos recogidos por el 'Xauen' en su campaña del otoño de 1952 (X-528)." Bol. Inst. Español Oceanogr., **69**. Madrid, 1955.

Hernandez-Pacheco, F. "Características del zócalo continental del África Occidental española." Bol. Inst. Español Oceanogr., **70**. Madrid, 1955.

Hill, M. N. "Notes on the bathymetric chart of the N. E. Atlantic." Deep-Sea Res., **3**: 229–31. London & New York, 1956.

Holtedahl, H. "On the Norwegian continental terrace, primarily outside Møre – Romsdal: its geomorphology and sediments. With contributions on the quaternary geology of the adjacent land and on the bottom deposits of the Norwegian Sea". Univ. Bergen, Årbok 1955, (14). Bergen, 1956.

Koczy, F. F. "Geochemistry of the radioactive elements in the ocean". Deep-Sea Res., **3**: 93–103. London & New York, 1956.

Kuenen, P. H. "Recent advances in deep-sea sedimentology". Proc. Roy. Soc., Ser. A, **222** (1150): 289. London, 1954.
Kuenen, P. H. "Recent and ancient sedimentation; two aspects of one subject". J. Mar. Res., **14** (4): 440–5. New Haven, Conn., 1955.
Kullenberg, B. "A new core-sampler". Medd. Oceanogr. Inst. Göteborg, **26**. Göteborg, 1955.
Lisicyn, A. P., Peletin, V. P., & Udincev, G. B. "A new achievement of Soviet marine geology (the Sysoyev-Kudinov hydrostatic core-sampler)". Priroda, 6: 63–6. Moscow, 1954.
Lyman, J. "The deepest sounding in the North Atlantic". Proc. Roy. Soc., Ser. A, **222** (1150): 334. London, 1954.
Ostrekhim, M. Y. "Bathymétrie et glaciologie de la Partie Centrale de l'Océan Archtique". Priroda, 12. Moscow, 1954.
Revelle, R. "On the history of the oceans". J. Mar. Res., **14** (4): 446–61. New Haven, Conn., 1955.
Richards, F. A., & Vavvaro, R. F. "The Cariaco Trench, an anaerobic basin in the Caribbean Sea." Deep-Sea Res., **3**: 214–28. London & New York, 1956.
Saks, V. N., *et al.* "Current views on the geology of the central Arctic". Priroda, 7: 13–22. Moscow, 1955.
Shurbet, G., & Worzel, J. L. "Submarine topography west of Mexico and Central America". Bull. Geol. Soc. America, **66**: 773–6. New York, 1955.
Starikova, N. D. "Organic substance in the depth of deposits of the Bering Sea". Dokl. Akad. Nauk SSSR, **106** (3): 519. Moscow, 1956.
Wiseman, J. D. H. "The determination and significance of past temperature changes in the upper layer of the equatorial Atlantic Ocean". Proc. Roy. Soc., Ser. A, **222** (1150): 296. London, 1954.

2) d Sea Water, Physics

Abe, T. "A study on the foaming of sea water (12th report). A tentative analysis of wind wave data in view of the foaming of sea water. Part 2". J. Oceanogr. Soc. Japan, **12** (2): 39–44. Tokyo, 1956.
Arons, A. B., & Kientzler, C. F. "Vapor pressure of sea-salt solutions". Trans. American Geophys. Union, **35** (5): 722–8. Washington, 1954.
Banner, A. H. "Note on a visible thermocline". Science, **121** (3142): 402–3. Washington, 1955.
Clarke, G. L., & Wertheim, G. K. "Measurement of illumination at great depths and at night in the Atlantic Ocean by means of a new bathyphotometer." Deep-Sea Res., **3**: 189–205. London & New York, 1956.
Cromwell, T. "Pycnoclines created by vertical mixing". Trans. American Geophys. Union, **37** (3): 340. Washington, 1956.
la Fond, E. C. "Bathythermograms – an oceanographic tool". Current Sci., **25** (2): 40–1. Bangalore, 1956.
Franceschini, G. A. "Reliability of commercial vessel reports of sea surface temperatures in the Gulf of Mexico". Bull. Mar. Sci. Gulf & Caribbean, **5** (1): 42–51. Coral Gables, Fla., 1955.
Hamon, B. V. "Portable temperature-chlorinity bridge for estuarine investigations and sea-water analysis". J. Sci. Instr., **33**: 329–32. London, 1956.
Ivanoff, A. "Au sujet de la pénétration de la lumière dans la mer". C. R. Acad. Sci., **241**: 1612–4. Paris, 1955.
Jerlov, N. G. "Factors influencing the transparency of the Baltic waters". Medd. Oceanogr. Inst. Göteborg, **25**. Göteborg, 1955.
Jones, D., & Wills, M. S. "The attenuation of light in sea and estuarine waters in relation to the concentration of suspended solid matter". J. Mar. Biol. Assoc., **35** (2): 431–44. Cambridge, 1956.
Koczy, F. F. "Vertical eddy diffusion in deep water". Nature, **178**: 585–6. London, 1956.
Landais, J. "Mesure de coefficient d'extinction de l'eau de la Méditerranée dans la région de Banyuls". Vie et Milieu, **6**: 210–24. Paris, 1955.

Lenoble, J. "Sur quelques nouvelles mesures de la pénétration du rayonnement ultraviolet dans la Méditerranée et leur interprétation théoretique". C. R. Acad. Sci., **241**: 1407–9. Paris, 1955.

Mandelbaum, H. "Evidence for a critical wind velocity for air-sea boundary processes". Trans. American Geophys. Union, **37** (3): 354. Washington, 1956.

Model, F. "Wärmeumsatz zwischen Meer und Atmosphäre im Atlantischen Südpolarmeer und im Nordpolarmeer". Ann. Meteorol., **7**: 64–6. Hamburg, 1956.

Neiburger, M. "A note on the reflection of diffuse radiation by the sea surface". Trans. American Geophys. Union, **35** (5): 729–32. Washington, 1954.

Neumann, G. "On the mutual adjustment of the horizontal field of mass, the sea-surface topography, and the level of no motion in the Gulf Stream". Trans. American Geophys. Union, **37** (3): 355. Washington, 1956.

Saito, Y. "On the stability oscillations in the sea". J. Inst. Polytechn., **B1**: 33–42. Osaka, 1950.

Smith, P. F., Richard, J. D., & Stephens, F. H. "A technique for the spectral analysis of sound in the ocean". Trans. American Geophys. Union, **36** (3): 413–8. Washington, 1955.

Weber, W. "Die Temperaturabhängigkeit der Viskosität des Wassers zwischen 0° und 40° C." Zeitschr. Angew. Physik, **7** (2): 96. München, 1955.

Worthington, L. V. "The temperature increase in Caribbean deep water since 1933." Deep-Sea Res., **3**: 234–5. London & New York, 1956.

2) e Sea Water, Chemistry

Barnes, H. "Sea water". Analyst, **80** (946): 3. Cambridge, 1955. (Also: Collect. Repr. Scottish Mar. Biol. Assoc. 1955, 189.)

Barnes, H. "Chemical aspects of oceanography". Roy. Inst. Chem., Lect., Monogr., & Rep. 1955, 4. London, 1955. (Also: Collect. Repr. Scottish Mar. Biol. Assoc. 1955, 206).

Brown, R. M., & Grummitt, W. E. "The determination of tritium in natural waters". Canadian J. Chem., **34**: 220–6. Ottawa, 1956.

Burkholder, P. R., & Burkholder, L. M. "Microbiological assay of vitamin B_{12} in marine solids". Science, **123** (3207): 1071. Lancaster, Pa., 1956.

Chierego, N. "La determinazione del rame in materiale biologico e nelle acque". Pubbl. Ist. Speriment. Talassogr. Trieste, **322**. Trieste, 1955.

Emery, K. O., Orr, W. L., & Rittenberg, S. C. "Nutrient budgets in the ocean." Essays Natur. Sci. Allan Hancock: 299–310. Los Angeles, 1955.

Fukai, R. "Critical studies on the analytical methods for minor chemical constituents in sea water (part 3). Remarks on the method of estimation of nitrate-nitrogen by means of reduced strychnine reagent." J. Oceanogr. Soc. Japan, **11** (1): 19–23. Tokyo, 1955.

Fukai, R., & Shiokawa, F. "On the main chemical components dissolved in the adjacent waters to the Aleutian Islands in the North Pacific." Bull. Chem. Soc. Japan, **28** (9): 636–40. Tokyo, 1955.

Hood, D. W., Rona, E., & Akers, L. K. "Determination of manganese in sea water". Trans. American Geophys. Union, **37** (3): 349. Washington, 1956.

Kirsch, M. "Ionic ratios of some of the major components in river-diluted sea water in Bute and Knight Inlets, British Columbia." J. Fish. Res. Board Canada, **13** (3): 273–89. Ottawa, 1956.

Koczy, F. F. "The specific alkalinity." Deep-Sea Res., **3**: 279–88. London, 1956.

Krauskopf, K. B. "Factors controlling the concentrations of thirteen rare metals in sea water." Geochim. Cosmochim. Acta, **9**: 1–32. London, 1956.

Laevastu, T., & Thompson, T. G. "The determination and occurrence of nickel in sea water, marine organisms, and sediments." ICES, J. du Cons., **21** (2): 125–43. Copenhague, 1956.

Lehr, E., & Wegner, H.-J. "Der Keimgehalt des Meerwassers und seine Bedeutung für die Hochseefischerei." Die Fischwirtschaft, **6** (7): 73. Bremerhaven, 1954.

Lincoln, J. H., Paquette, R. G., & Rattray, M. "Microsalinometer for oceanographic model studies." Trans. American Geophys. Union, **36** (3): 406–12. Washington, 1955.

Picotti, M. "Ricerche spettrofotometriche e spettrografiche sul rame e vanadio biologico e delle acque." Pubbl. Ist. Speriment. Talassogr. Trieste, **327**. Trieste, 1956.
Ponomarenko, L. S., Sopach, E. D., & Istoshina, M. A. "Modification of the argentometric method for determining the salinity of sea water by the chlorine content." Meteorol. Gidrol., **10**: 54–5. Leningrad, 1953.
Robineau, C., & Desbois, C. "Étude sur la présence de l'or dans l'eau de mer." Trav. Centre Recherch. d'Études Océanogr., **2** (3). Paris, 1955.
Truesdale, G. A., & Knowles, G. "Some recent work on dissolved oxygen in natural waters." ICES, J. du Cons., **21** (3): 263–7. Copenhague, 1956.
Tsujita, T. "Studies on naturally occurring suspended organic matter in the waters adjacent to Japan. 3. On a process of organization of planktogenic organic matter as examined by the electron microscope." J. Oceanogr. Soc. Japan, **11** (4): 199–203. Tokyo, 1955.
Waldichuk, M. "Basic productivity of Trevor Channel and Alberni Inlet from chemical measurements." J. Fish. Res. Board Canada, **13** (1): 7–20. Ottawa, 1956.

2) f Structure, Dynamics, and Circulation

Andersen, K. P., Craig, R. E., Dannevig, A., Dietrich, G., Goedecke, E., Jerlov, N., Johnston, R., Smed, J., Tait, J. B., & Thomsen, H. "Near northern seas. Hydrography." ICES, Ann. Biol., **11**: 33–52. Copenhague, 1956.
Andersen, K. P., Hermann, F., McIntyre, A. D., Smed, J., Steele, J. H., & Stefánsson, U. "Distant northern seas. Hydrography." ICES, Ann. Biol., **11**: 11–26. Copenhague, 1956.
Anon. "Oceanographic survey of the Gulf of Mexico. Physical and meteorological data (cruises 54–2, 54–9 and 54–10)." A. & M. College Texas, Dept. Oceanogr., Project 24. Austin, 1956.
Anon. "Températures de l'eau autour de l'Amérique du Nord." Fish. Res. Board Canada, Progr. Rep. Atlantic Coast Stat., **64**: 16–8. St. Andrews, 1956.
von Arx, W. S., Bumpus, D. F., & Richardson, W. S. "On the fine-structure of the Gulf Stream front." Deep-Sea Res., **3** (1): 46–65. London & New York, 1955.
Bailey, W. B. "On the origin of deep Baffin Bay water." J. Fish. Res. Board Canada, **13** (3): 303–8. Ottawa, 1956.
Balay, M. A. "Topografia dinamica del Mar Argentino." Bol. Centro Naval, **71** (616). Buenos Aires, 1954.
Barber, F. G. "Seasonal temperature and salinity variations in Queen Charlotte Strait, B. C." Fish. Res. Board Canada, Progr. Rep. Pacific Coast Stat., **105**: 14–5. Ottawa, 1956.
Barlow, E. W. "Currents of the western South Pacific." Mar. Observ., **26** (174): 224–6. London, 1956.
Bass, J. "Sur les équations fonctionelles des fluides turbulents." C. R. Acad. Sci., **237**: 645. Paris, 1953.
Bernard, F. "Eaux atlantiques et méditerranéennes au large de l'Algérie. II. Courants et nannoplancton de 1951 à 1953." Ann. Inst. Océanogr., **31** (4). Paris, 1956.
Bjørgum, O. "On the differential equations for the velocity field in flows of fairly general liquids." Univ. Bergen, Årbok 1955, (3). Bergen, 1956.
Bjørgum, O. "On the physical boundary conditions in fluid dynamics." Univ. Bergen, Årbok 1955, (4). Bergen, 1956.
Bowden, K. F. "Physics in oceanography." British J. Appl. Phys., **7**: 273–81. 1956.
Bowden, K. F. "The flow of water through the Straits of Dover related to wind and differences in sea level." Phil. Trans. Roy. Soc. London, Ser. A, **248** (953): 517–51. London, 1956.
Bowden, K. F., & Fairbairn, L. A. "Measurements of turbulent fluctuations and Reynolds stresses in a tidal current." Proc. Roy. Soc., Ser. A, **237**: 422–4. London 1956.
Broc, J. "Mesure des courants marins par radar." Bull. Inst. Océanogr., **1029**. Monaco, 1953.
Bumpus, D. F. "The circulation over the continental shelf south of Cape Hatteras." Trans. American Geophys. Union, **36** (4): 601–11. Washington, 1955.
Carruthers, J. N. "'Bottle post' and other drifts". J. Inst. Navig., **9** (3): 261–81. London, 1956.

Charney, J. G. "The generation of ocean currents by wind." J. Mar. Res., **14** (4): 477–98. New Haven, Conn., 1955.

Chew, F. "The possible role of inertial transverse motion in the Florida current." Mar. Lab. Univ. Miami, Techn. Rep., 56–15: 19–27. Coral Gables, 1956.

Chew, F., & Wagner, L. P. "Tropical oceanography. Semi-annual report of investigation between the period of 15 May 1955 to 15 November 1955." Mar. Lab. Univ. Miami, Techn. Rep., 56–15. Coral Gables, 1956.

Cooper, L. H. N. "Deep water movements in the North Atlantic as a link between climatic changes around Iceland and biological productivity of the English Channel and Celtic Sea." J. Mar. Res., **14** (4): 347–62. New Haven, Conn., 1955.

Cooper, L. H. N. "On assessing the age of deep oceanic water by carbon-14." J. Mar. Biol. Assoc., **35** (2): 341–54. Cambridge, 1956.

Cromwell, T., & Reid, J. L. "A study of oceanic fronts." Tellus, **8** (1): 94–101. Stockholm, 1956.

Cubillos, M. R. "Estudios sobre la temperatura superficial del agua de mar en las vecindades de la estación de Montemar." Rev. Biol. Mar., **5**: 58–67. Valparaiso, 1955.

Deacon, G. E. R., *et al.* "Discussions on the relationships between meteorology and oceanography." J. Mar. Res., **14** (4): 499–515. New Haven, Conn., 1955.

Dietrich, G., Granqvist, G., Kändler, R., Koczy, F., & Thomsen, H. "Baltic-Belt seas. Hydrography." ICES, Ann. Biol., **11**: 72–7. Copenhague, 1956.

Dodimead, A. J. "Project NorPac." Fish. Res. Board Canada, Progr. Rep. Pacific Coast Stat., **105**: 16–8. Ottawa, 1956.

Eckart, C. "Statistical hydrodynamics." J. Mar. Res., **14** (4): 295–301. New Haven, Conn., 1955.

Ehrlich, A. "Subsurface density inversions off Nantucket Island." Trans. American Geophys. Union, **35** (4): 573–84. Washington, 1954.

Fleming, R. H. "Review of the oceanography of the northern Pacific." Internat. North Pacific Fish. Comm., Bull., **2**. Vancouver, 1955.

Freeman, J. C. "Note on a prediction equation for the surface layer of a two-layer ocean." Trans. American Geophys. Union, **35** (4): 585–7. Washington, 1954.

Gautier, Y. "Sur quelques lachers de cartes du type 'Siphonophore' en vue de l'étude des courants de surface devant le delta du Rhône." Rec. Trav. Stat. Mar. d'Endoume, Bull., 11: 135–44. Marseille, 1956.

Goedecke, E. "Über langjährige Temperatur- und Salzgehaltsanomalien im Oberflächenwasser der Irischen See." Deutsche Hydrogr. Zeitschr., **9** (3): 121–32. Hamburg, 1956.

Hasle, G. R. "Phytoplankton and hydrography of the Pacific part of the Antarctic Ocean." Nature, **177**: 616–7. London, 1956.

Heezen, B. C., & Ewing, M. "Orleansville earthquake and turbidity currents." Bull. American Assoc. Petrol. Geol., **39**: 2005–14. Chicago, 1955.

Hela, I. "A pattern of coastal circulation inferred from synoptic salinity data." Bull. Mar. Sci. Gulf & Caribbean, **6** (1): 74–83. Coral Gables, Fla., 1956.

Hela, I., Wagner, L. P., & Chew, F. "Tropical oceanography." Univ. Miami Mar. Lab., Techn. Rep., 55–27. Coral Gables, 1955.

Hidaka, K. "A contribution to the theory of upwelling and coastal currents." Trans. American Geophys. Union, **35** (3): 431–44. Washington, 1954.

Hishida, K. "Annual variation of sea-surface water temperature and air temperature in the western parts of Pacific Ocean." Rec. Oceanogr. Works Japan, **2** (3): 79–84. Tokyo, 1955.

Ichiye, T. "A note on the stationary currents in an estuary." J. Oceanogr. Soc. Japan, **11** (4): 141–5. Tokyo, 1955.

Iselin, C. O'D. "Recent advances in our understanding of the circulation problem and their impiications." J. Mar. Res., **14** (4): 315–22. New Haven, Conn., 1955.

Iwata, N. "Das Spektrum der Schwankungen der japanischen Meeresströmung vom Gesichtpunkt der Turbulenztheorie aus." J. Oceanogr. Soc. Japan, **12** (2): 33–7. Tokyo, 1956.

Jerlov, N. G. "The equatorial currents in the Pacific Ocean." Rep. Swedish Deep-Sea Exped., **3**, Phys. & Chem., (6). Göteborg, 1956.

Johnson, M. W. "The plankton of the Beaufort and Chukchi Sea areas of the Arctic and its relation to the hydrography." Arctic Inst. North America, Techn. Pap., **1**. Montreal, 1956.

Ketchen, K. S. "Climatic trends and fluctuations in yield of marine fisheries of the northeast Pacific." J. Fish. Res. Board Canada, **13** (3): 357–74. Ottawa, 1956.

Kitou, M. "The correlation of the oceanographical conditions to the distribution of plankton larvae of littoral benthos in Enshū-nada." J. Oceanogr. Soc. Japan, **12** (2): 59–62. Tokyo, 1956.

Knauss, J. A. "Some GEK observations of the equatorial countercurrent in the eastern Pacific." Trans. American Geophys. Union, **37** (3): 351. Washington, 1956.

Kuenen, P. H. "The difference between sliding and turbidity flow." Deep-Sea Res., **3**: 134–9. London & New York, 1956.

Lafuste, J. G., & Letaconnoux, R. "Comité Atlantique. Hydrologie." ICES, Ann. Biol., **11**: 84–6. Copenhague, 1956.

Lawford, A. L. "The effect of wind upon the surface drift in the northeastern Atlantic and the North Sea." Weather, **11** (5): 155–61. London, 1956.

Lawford, A. L., & Veley, V. F. C. "The relationship between local wind and current in coastal waters of the British Isles." Nation. Inst. Oceanogr., Internal Rep. A 3. Wormley, Godalming, 1955.

Leipper, D. F. "Sea temperature variations associated with tidal currents in stratified shallow water over an irregular bottom." J. Mar. Res., **14** (3): 234–52. New Haven, Conn., 1955.

Lewis, G. J., & Rakestraw, N. W. "Carbohydrate in sea water." J. Mar. Res., **14** (3): 253–8. New Haven, Conn., 1955.

Lumby, J. R. "A note on synoptic hydrographic charts." ICES, J. du Cons., **21** (3): 250–62. Copenhague, 1956.

MacGregor, D. G. "Currents and transport in Cabot Strait." J. Fish. Res. Board Canada, **13** (3): 435–48. Ottawa, 1956.

Mao, H., & Yoshida, K. "Physical oceanography in the Marshall Islands area." Geolog. Surv. Prof. Pap. (1954–1955), 260-R.

Martelly, J. "La corriente de Humboldt, contribución a su conocimiento experimental y ensayo sobre su teoría mecánica." Rev. Biol. Mar., **5**: 17–57. Valparaiso, 1955.

McGary, J. W., & Stroup, E. D. "Mid-Pacific oceanography, Part VIII, middle latitude waters, January-March 1954." US Dept. Inter., Fish and Wildl. Serv., Spec. Sci. Rep.-Fish., **180**. Washington, 1956.

McLellan, H. J. "On the sharpness of oceanographic boundaries south of Nova Scotia." J. Fish. Res. Board Canada, **13** (3): 297–301. Ottawa, 1956.

Metcalf, W. G. "On the formation of bottom water in the Norwegian Basin." Trans. American Geophys. Union, **36** (4): 596–600. Washington, 1955.

Mosby, H. "Les problèmes d'interprétation en océanographie physique". Trav. Centre Rech. d'Études Océanogr., **2** (4). Paris, 1955.

Neumann, G. "Notes on the horizontal circulation of ocean currents." Bull. American Meteorol. Soc., **37**: 96–100. Easton, Pa., 1956.

Neumann, J., & Rosenan, N. "The Black Sea: energy balance and evaporation." Trans. American Geophys. Union, **35** (5): 767–74. Washington, 1954.

Noodt, E. "Temperatur- und Salzgehaltsanomalien in Tiefenhorizonten des Atlantischen Ozeans". Dissert., Phil. Fac. Chr. Albrechts-Univ., 59 pp. Kiel, 1955.

O'Hara, J. E., Carlson, Q. H., & Tamblyn, W. E. "Some results of a tanker survey of the Gulf Stream." Trans. American Geophys. Union, **35** (3): 420–30. Washington, 1954.

Palmén, E. "On the exchange of momentum between the atmosphere, the oceans, and the solid earth." J. Mar. Res., **14** (4): 465–76. New Haven, Conn., 1955.

Riehl, H. "Sea surface temperatures of the North Atlantic 1887–1936." Univ. Chicago. 1956.

van Riel, P. M. "Oceanographic results. Part 5: The bottom water. Chapter II: Temperature." Snellius Exped. Eastern East Indian Archipelago 1929–1930, **2**. Leiden, 1956.

Rittenberg, S. C., Emery, K. O., & Orr, W. L. "Regeneration of nutrients in sediments of marine basins." Deep-Sea Res., **3** (1): 23–45. London & New York, 1955.

Robson, A. D. "The effect of water temperature upon the calibration of a current meter." Trans. American Geophys. Union, **35** (4): 647–8. Washington, 1954.

Robson, R. "Radar methods in ocean current detection." Commonwealth Engin., **42** (6). Melbourne, 1955.
Rodewald, M. "Klimaschwankungen und nördliche Fischereigebiete." Die Fischwirtschaft, **5** (12): 290. Bremerhaven, 1953.
Rodewald, M. "Beiträge zur Klimaschwankung im Meere. Die nordatlantische Temperaturanomalie in den Jahren 1954 und 1955." Deutsche Hydrogr. Zeitschr., **9** (3): 137–42. Hamburg, 1956.
Romanovsky, V. "Résultats de la détermination dans le bassin occidental de la Méditerranée des courants superficiels par la méthode des flotteurs dérivants." Trav. Centre Rech. d'Études Océanogr., **11** (1–2). Paris, 1955.
Saint-Guily, B. "Sur la théorie des courants marins induits par le vent." Bull. d'Inform. (COEC), **8** (3): 111–23. Paris, 1956.
Saito, Y. "On the velocity of the vertical flow in the ocean." J. Inst. Polytechn., B2: 1–4. Osaka, 1951.
Saito, Y. "On homogeneous layers in the troposphere and 'Deckschicht' in the ocean." J. Inst. Polytechn., G1: 1–8. Osaka, 1954.
Saito, Y. "On the Oyashio current. II. Theoretical consideration on the currents near the polar front." J. Inst. Polytechn., G2: 1–11. Osaka, 1954.
Schweigger, E. "El aspecto hidrografico de la zona de pesca situada entre Ilo e Iquique." Rev. Biol. Mar., **5**: 10–6. Valparaiso, 1955.
Seckel, G. R. "Mid-Pacific oceanography, Part VII. Hawaiian offshore waters September 1952 – August 1953." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., **164**. Washington, 1955.
Shepard, F. P. "High-velocity turbidity currents, a discussion." Proc. Roy. Soc., Ser. A, **222** (1150): 323. London, 1954.
Soeriaatmadja, Rd. E. "Seasonal fluctuations in the surface salinity off the north coast of Java." Mar. Res. Indonesia, **1**: 1–19. Djakarta, 1956.
Soot-Ryen, T. "Report on the hydrographical conditions in West-Finnmark March-April, 1935." Acta Borealia, A. Scientia, 10. Tromsø, 1956.
Stommel, H. "Lateral eddy viscosity in the Gulf Stream system." Deep-Sea Res., **3** (1): 88–90. London & New York, 1955.
Stommel, H., Arons, A. B., & Blanchard, D. "An oceanographical curiosity: the perpetual salt fountain." Deep-Sea Res., **3**: 152–3. London & New York, 1956.
Swallow, J. C. "A neutral-buoyancy float for measuring deep currents." Deep-Sea Res., **3** (1): 74–81. London & New York, 1955.
Takano, K. "Influence des échanges thermiques, de la précipitation et de l'évaporation sur la circulation générale dans les océans." C. R. Acad. Sci., **242** (18). Paris, 1956.
Trites, R. W. "The oceanography of Chatham Sound, British Columbia." J. Fish. Res. Board Canada, **13** (3): 385–434. Ottawa, 1956.
Veronis, G. "Partition of energy between geostrophic and non-geostrophic oceanic motions." Deep-Sea Res., **3**: 157–77. London & New York, 1956.
Veronis, G. "The response of a stratified ocean to a transient wind stress." Trans. American Geophys. Union, **37** (3): 361. Washington, 1956.
Volkmann, G., Knauss, J., & Vine, A. "The use of parachute drogues in the measurement of subsurface currents." Trans. American Geophys. Union, **37** (3): 362. Washington, 1956.
Waldichuk, M., & Tabata, S. "Oceanography of the Strait of Georgia: V. Surface currents." Fish. Res. Board Canada, Progr. Rep. Pacific Coast Stat., **104**: 30–3. Ottawa, 1955.
Worthington, L. V. "A new theory of Caribbean bottom-water formation." Deep-Sea Res., **3** (1): 82–7. London & New York, 1955.
Wyrtki, K. "Monthly charts of surface salinity in Indonesian and adjacent waters." ICES, J. du Cons., **21** (3): 268–79. Copenhague, 1956.
Wyrtki, K. "The subtropical lower water between the Philippines and Irian (New Guinea)." Mar. Res. Indonesia, **1**: 21–52. Djakarta, 1956.

2) g Waves, Tides, and Sea-Level

Anon. "On the variations of the normal height of the sea-level round the Danish coasts 1889–1954." Nautisk-Meteorol. Årbog 1955, App. Charlottenlund, 1956.
Balay, M. A. "Ondos de tormenta en el Rio de la Plata. Su previsión por el pronostico meteorológico." Bol. Centro Naval, **72** (619). Buenos Aires, 1954.

Balay, M. A. "La determinación del nivel medio del mar Argentino." Argentine Min. Mar., Dept. Oceanogr., 45 pp. Buenos Aires, 1955.

Banal, M. "Mesure de la houle au bateau-feu du Havre." Bull. d'Inform., (COEC), **8** (7): 314–26. Paris, 1956.

Barber, N., & Doyle, D. "A method of recording the direction of travel of ocean swell." Deep-Sea Res., **3**: 206–13. London & New York, 1956.

Bergsten, F. "Winds and water levels on the coast of Sweden." Geogr. Ann., **37** (3–4): 119–40. Stockholm, 1955.

Bonnefille, R. "Étude de la circulation des courants dans la Manche en tenant compte du frottement sur le fond et de la force de Coriolis." Bull. d'Inform., (COEC), **8** (7): 306–13. Paris, 1956.

Brown, A. L., *et al.* "Power spectrum analysis of internal waves from operation standstill." US Hydrogr. Off., TR-26. Washington, 1955.

Cartwright, D. E. "On determining the directions of waves from a ship at sea." Proc. Roy. Soc., Ser. A, **234**: 382–7. London, 1956.

Crease, J. "Propagation of long waves due to atmospheric disturbances on a rotating sea." Proc. Roy. Soc., Ser. A, **233**: 556–69. London, 1956.

Disney, L. P. "Tide heights along the coasts of the United States." Proc. American Soc. Civil Engin., **81**: 666. New York, 1956.

Doniol, R. "Les variations saisonnières du niveau moyen à Dakar." Bull. d'Inform., (COEC), **8** (5): 225–40. Paris, 1956.

Donn, W. L. "On the prediction of storm tides generated by 'northeast storms'". Trans. American Geophys. Union, **37** (3): 342. Washington, 1956.

Dorrestein, R. "Bemerkungen zu den Wellenbeobachtungen der Wetterschiffe im östlichen Nordatlantik." Deutsche Hydrogr. Zeitschr., **8** (5): 177–86. Hamburg, 1955.

Farquharson, W. I. "Vertical movements of the sea." Commonwealth Survey Officers' Conf. 1955, Pap., 27. 1955.

Fleagle, R. G. "Note on the effect of air-sea temperature difference on wave generation." Trans. American Geophys. Union, **37** (3): 275–7. Washington, 1956.

Freeman, J. C., & Baer, L. "Graphical computation of hurricane storm tides." Trans. American Geophys. Union, **37** (3): 344. Washington, 1956.

Harris, D. L. "The storm-surge problem in the United States." Trans. American Geophys. Union, **37** (3): 347. Washington, 1956.

Hodgkin, E. P. "A portable recording tide gauge." Australian J. Mar. Freshw. Res., **7** (1): 147–50. Melbourne, 1956.

Ishiguro, S. "An electronic recorder for sea wave pressure, Type 3." J. Oceanogr. Soc. Japan, **12** (1): 7–12. Tokyo, 1956.

Ishiguro, S., & Fujiki, A. "An analytical method for the oscillations of water in a bay or lake, using an electric network and an electric analogue computer." J. Oceanogr. Soc. Japan, **11** (4): 191–7. Tokyo, 1955.

Ishiguro, S., Fujiki, A., & Nagata, M. "An electronic measuring apparatus for sea wave pressure, Type 6". J. Oceanogr. Soc. Japan, **12** (1): 13–8. Tokyo, 1956.

Keulegan, G. H. "An experimental study of internal solitary waves." Rep. Nation. Bur. Stand., **4415**. 1955.

Lacombe, H. "Fluctuations de niveau sur la côte marocaine en 1953." Bull. d'Inform., (COEC), **8** (3): 124–8. Paris, 1956.

Lisitzin, E. "L'analogie des moyennes mensuelles du niveau de la mer dans la Baltique, la mer du Nord et la Manche." Bull. d'Inform., (COEC), **8** (4): 160–8. Paris, 1956.

Miyazaki, M. "Seasonal variations of the sea level along the Japanese coasts." Rec. Oceanogr. Works Japan, **2** (3): 1–8. Tokyo, 1955.

Miyazaki, M. "Harmonic analysis of tides by use of the data for a month." J. Oceanogr. Soc. Japan, **12** (1): 1–6. Tokyo, 1956.

Munk, W. H. "High frequency spectrum of ocean waves". J. Mar. Res., **14** (4): 302–14. New Haven, Conn., 1955.

Rattray, M. "A comparison of methods for forecasting wave generation." Deep-Sea Res., **3**: 140–4. London & New York, 1956.

Reid, J. L. "Observations of internal tides in October 1950." Trans. American Geophys. Union, **37** (3): 278–86. Washington, 1956.

Stoker, J. J. "Water waves." New York Univ., 670 pp. Interscience Publ. Ltd., London, 1956.

Takashima, S., Hagino, Y., & Hashizume, G. "Quantitative analysis of KCl and NaCl mixtures with the x-ray spectrophotometer." Rec. Oceanogr. Works Japan, **2** (3): 45–8. Tokyo, 1955.

Walden, H. "Die Höhe der Windsee bei gleichmässig zunehmendem Wind." Deutsche Hydrogr. Zeitschr., **8** (6): 236–41. Hamburg, 1955.

Walden, H. "Ein neues Diagramm zur Berechnung des Seegangs aus den Windverhältnissen." Ann. Meteorol., **7** (3/4): 213–8. Hamburg, 1956.

Walden, H. "Zur Bandbreite des Periodenspektrums in der Dünung." Deutsche Hydrogr. Zeitschr., **9** (3): 132–6. Hamburg, 1956.

Watanabe, K. "A theory of the under-water unit with a slow-leak for wave recorders." J. Oceanogr. Soc. Japan, **12** (1): 19–22. Tokyo, 1956.

Wilson, B. W. "Generation of long-period seiches in Table Bay, Cape Town, by barometric oscillations." Trans. American Geophys. Union, **35** (5): 733–46. Washington, 1954.

Yakame, K. "An automatic tide station." J. Meteorol. Soc. Japan, Ser. 2, **33** (5). Tokyo, 1955.

2) h Ice

Brown, A. L. "An analytical method of ice potential calculation." Techn. Rep. US Navy Hydrogr. Off., **5**. Washington, 1954.

Browne, I., & Crary, A. P. "Arctic ice-pack-movement studies." Trans. American Geophys. Union, **37** (3): 338. Washington, 1956.

Corton, E. L. "The ice budget of the arctic pack and its application to ice forecasting." Techn. Rep. US Navy Hydrogr. Off., **6**. Washington, 1954.

Dunbar, M. "The pattern of ice distribution in Canadian arctic seas." Trans. Roy. Soc. Canada, Ser. 3, **48**: 9–18. Ottawa, 1954.

Fukutomi, T., *et al.* "A report on the survey of sea ice on the Okhotsk Sea coast of Hokkaido." Low Temp. Sci., Ser. A, **13**: 59–103. Sapporo, 1954.

Koenig, L. S. "Ice islands in the Arctic Ocean." Coll. American Assoc. Advancem. Sci., Alaska Div., Proc. 2nd. Alaskan Sci. Conf: 263–70. 1953.

Kusunoki, K. "Observations on the horizontal and vertical distribution of chlorinity of sea ice." J. Oceanogr. Soc. Japan, **11** (4): 179–83. Tokyo, 1955.

Kusunoki, K. "Recent advances in the study of sea ice." Low Temp. Sci., Ser. A, **14**: 155–84. Sapporo, 1955.

Leipper, D. F. "Sea temperature, statistics, and shallow-water tidal currents". Trans. American Geophys. Union, **37** (3): 353. Washington, 1956.

Nusser, F. "Die Eisverhältnisse des Winters 1952/53 an den deutschen Küsten zwischen Ems und Trave." Deutsche Hydrogr. Zeitschr., **8** (2): 65–72. Hamburg, 1955.

Ostrekhim, M. Y. "Bathymétrie et glaciologie de la partie centrale de l'Océan Arctique." Priroda, 12. Moscow, 1954.

Post, L. A. "The role of the Gulf Stream in the prediction of iceberg distribution in the North Atlantic." Tellus, **8** (1): 102–11. Stockholm, 1956.

Rodhe, B. "A study of the correlation between the ice extent, the course of air temperature and the sea surface temperature in the Åland Archipelago." Geogr. Ann., **37** (3–4): 141–64. Stockholm, 1955.

Romanovsky, V. "Conservation des échantillons d'eau de mer dans les flacons en polyethylène." Trav. Centre Rech. d'Études Océanogr., **1** (12). Paris, 1954.

Schell, I. I. "Interrelations of Arctic ice with the atmosphere and the ocean in the North Atlantic Arctic and adjacent areas." J. Meteorol., **13**: 46–58. Lancaster, Pa., 1956.

Schule, J. J. "Comparison of sea-ice conditions in the American Arctic, 1953–55". Trans. American Geophys. Union, **37** (3): 357. Washington, 1956.

Tabata, T. "A measurement of visco-elastic constants of sea ice." J. Oceanogr. Soc. Japan, **11** (4): 185–9. Tokyo, 1955.

Thomsen, H., & Lorck, M. V. L. "Isforholdene i de arktiske have 1953." Publ. Danske Met. Inst. Charlottenlund, 1956.

Wallen, C. C., & Ahlmann, H. W. "Some recent studies in Sweden of the present climatic fluctuation." Arch. Meteorol. Geophys. Bioklimat., Ser. B, **6** (1–2): 7–21. Wien, 1954.

Zubov, N. N. "Arctic ice islands and the character of their drift." Priroda, 2: 37–45. Moscow, 1955.

2) i Coastal Oceanography and Limnology

Chew, F. "Red tide and the fluctuation of conservative concentrations at an estuary mouth." Bull. Mar. Sci. Gulf & Caribbean, Univ. Miami, **5** (4): 321–30. Coral Gables, 1955.

Day, J. H., Millard, N. A. H., & Broekhuysen, G. J. "The ecology of South African estuaries. Part IV. The St. Lucia system." Trans. Roy. Soc. South Africa, **34** (1). Cape Town, 1955.

Fry, F. E. J. "Movement of drift cards in Georgian Bay in 1953." J. Fish. Res. Board Canada, **13** (1): 1–5. Ottawa, 1956.

Tabata, S. "Oceanographic conditions in Steveston Harbour during normal discharge of the Fraser River." Fish. Res. Board Canada, Progr. Rep. Pacific Coast Stat., **104**: 26–9. Ottawa, 1955.

Takano, K. "A complementary note on the diffusion of the seaward river flow off the mouth." J. Oceanogr. Soc. Japan, **11** (4): 147–9. Tokyo, 1955.

3) Plankton

3) a General

Creitz, G. I., & Richards, F. A. "The estimation and characterization of plankton populations by pigment analysis. III. A note on the use of 'millipore' membrane filters in the estimation of plankton pigments." J. Mar. Res., **14** (3): 211–6. New Haven, Conn., 1955.

Davis, C. C. "The marine and fresh-water plankton." Michigan State Univ. Press. East Lansing, 1955.

Einarsson, H. "Observations on plankton, temperature and the distribution of herring, made from the research vessel 'Ægir' during the summer of 1955." Fjölrit Fiskideildar, **7**. Reykjavik, 1956.

Fraser, J. H., Jensen, Aa. J. C., Rae, K. M., le Roux, S., & Wimpenny, R. S. "Plankton." ICES, Ann. Biol., **11**. Copenhague, 1956.

Glover, R. S., & Pope, J. A. "The Hardy plankton indicator: a study of the variation between catches taken by day and by night." Bull. Mar. Ecol., **4** (32): 115–33. Edinburgh, 1956.

Nishizawa, S., & Anraku, M. "A note on measuring of the volume of water filtered by plankton net by means of a flow meter." Bull. Fac. Fish. Hokkaido Univ., **6** (4): 298–309. Hakodate, 1955.

Okubo, A. "An additional note on the decomposition of sinking remains of plankton organisms and its relationship to nutriment liberation." J. Oceanogr. Soc. Japan, **12** (2): 45–7. Tokyo, 1956.

Williamson, D. I. "The plankton in the Irish Sea, 1951 and 1952." Bull. Mar. Ecol., **4** (31): 87–114. Edinburgh, 1956.

3) b Zooplankton

Anon. "Pelagic mollusca: swimmers and drifters." Nature, **177** (4518): 1023–5. London, 1956.

Banse, K. "Über den Transport von meroplanktischen Larven aus dem Kattegat in die Kieler Bucht." Ber. Deutschen Wiss. Komm. Meeresf., **14** (2): 147–64. Stuttgart, 1956.

Fisher, L. R. "The nature, distribution and sources of vitamin A and carotenoids in Euphausiacea." 3e Congr. Internat. Biochim., Bruxelles, 1–6 Août 1955.

Foxton, P. "The distribution of the standing crop of zooplankton in the Southern Ocean." Discovery Rep., **28**: 191–236. Cambridge, 1956.

Harris, J. E., & Mason, P. "Vertical migration in eyeless *Daphnia*." Proc. Roy. Soc., Ser. B, **145** (919): 280–90. London, 1956.

Margalef, R. "Rotiferos marinos del plancton de la Ria de Vigo." Invest. Pesqu., **4**: 133–5. Barcelona, 1956.

Mauchline, J. "Notes on the differences between *Calanus finmarchicus* (Gunn.) and *Calanus helgolandicus* (Claus)." Bull. Mar. Ecol., **4** (33): 135–40. Edinburgh, 1956.

Russell, F. S. "On the scyphomedusae *Nausithoë atlantica* Broch and *Nausithoë globifera* Broch." J. Mar. Biol. Assoc., **35** (2): 363–70. Cambridge, 1956.
Russell, F. S. "On a new medusa, *Amphinema krampi* n. sp.." J. Mar. Biol. Assoc., **35** (2): 371–4. Cambridge, 1956.
Wilson, D. P., & Wilson, M. A. "A contribution to the biology of *Ianthina janthina* (L.)." J. Mar. Biol. Assoc., **35** (2): 291–306. Cambridge, 1956.

3) c Phytoplankton

Atkins, W. R. G., & Jenkins, P. G. "Factors affecting the vernal phytoplankton outburst in the English Channel." Nature, **177** (4522): 1218–9. London, 1956.
Braarud, T. "Studiet av plankton-alger i elektronmikroskop." Blyttia, **12** (2): 102–8. Oslo, 1954.
Cushing, D. H. "Phytoplankton and the herring: Part V." MAFF, Fish. Invest., Ser. 2, **20** (4). London, 1956.
Droop, M. R. "Some factors governing encystment in *Haematococcus pluvialis*." Arch. Mikrobiol., **21**: 267–72. Berlin, 1955.
Duran, M., *et al.* "El fitoplancton de la Ria de Vigo, de abril de 1954 a junio de 1955." Invest. Pesqu., **3**: 67–96. Barcelona, 1956.
Hela, I. "Ecological observations on a locally limited red tide bloom." Bull. Mar. Sci. Gulf & Caribbean, **5** (4): 269–91. Coral Gables, Fla., 1955.
Holmes, R. W. "The annual cycle of phytoplankton in the Labrador Sea, 1950–51." Bull. Bingham Oceanogr. Collect., **16** (1). New Haven, Conn., 1956.
Hulburt, L. V., & Wilson, W. L. "The phytoplankton of Great Pond, Massachusetts." Biol. Bull., **110** (2): 157–68. Lancaster, Pa., 1956.
Jørgensen, E. G. "Variations in the silica content of diatoms." Physiol. Plantarum, **8** (4): 840–5. Copenhagen, 1955.
Jørgensen, E. G. "Solubility of the silica in the diatoms." Physiol. Plantarum, **8** (4): 846–51. Copenhagen, 1955.
Kingsbury, J. M. "On pigment changes and growth in the blue-green alga, *Plectonema nostocorum* Bornet et Gomont." Biol. Bull., **110** (3): 310–9. Lancaster, Pa., 1956.
Margalef, R. "Cultivos experimentales de algas unicelulares." Invest. Pesqu., **3**: 3–20. Barcelona, 1956.
Motoda, S., & Kawarada, Y. "Diatom communities in Aleutian waters on the basis of net samples collected in May-June 1953." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 191–200. Hakodate, 1955.
Munoz, F., Herrera, J., & Margalef, R. "Fitoplancton de las costas de Castellon durante el año 1954." Invest. Pesqu., **3**: 75–90. Barcelona, 1956.
Rossignol, M. "Sur la présence d'Ebriédiens dans le plancton de la baie de Pointe-Noire (A.E.F.)." Rev. Trav. Inst. Pêche Mar., **20** (1): 115–7. Paris, 1956.
Serenkov, G. P., & Pakhomova, M. V. "The nitrogenous complex of some species of diatoms." Vestnik Moskov. Univ., **10** (12), Ser. Fiz. Mat. Estestven. Nauk, **8**: 133–42. Moscow, 1955.
Takano, H. "Harmful blooming of minute cells of *Thalassiosira decipiens* in coastal water in Tokyo Bay." J. Oceanogr. Soc. Japan, **12** (2): 63–7. Tokyo, 1956.
Wilson, W. B., & Ray, S. M. "The occurrence of *Gymnodinium brevis* in the western Gulf of Mexico." Ecology, **37** (2): 388. Durham, N. C., 1956.
Wimpenny, R. S. "The size of diatoms. III. The cell width of *Biddulphia sinensis* Greville from the southern North Sea." J. Mar. Biol. Assoc., **35** (2): 375–86. Cambridge, 1956.

3) d Nanoplankton

Bernard, F. "Eaux Atlantiques et Méditerranéennes au large de l'Algérie. II. Courants et nannoplancton de 1951 à 1953." Ann. Inst. Océanogr., **31** (4). Paris, 1956.
Parke, M., Manton, I., & Clarke, B. "Studies on marine flagellates. III. Three further species of *Chrysochromulina*." J. Mar. Biol. Assoc., **35** (2): 387–414. Cambridge, 1956.

3) e Productivity

Blinks, L. R. "Photosynthesis and productivity of littoral marine algae." J. Mar. Res., **14** (4): 363–73. New Haven, Conn., 1955.

Kändler, O. "Über die Beziehungen zwischen Phosphathaushalt und Photosynthese (2)". Zeitschr. Naturf., **9** b (10): 625. Wiesbaden, 1954.
Kändler, O. "Über die Beziehungen zwischen Phosphathaushalt und Photosynthese (3). Hemmungsanalyse der lichtabhängigen Phosphorylierung." Zeitschr. Naturf., **10** b (1): 38. Wiesbaden, 1955.
Steemann Nielsen, E. "Production of organic matter in the oceans." J. Mar. Res., **14** (4): 374–86. New Haven, Conn., 1955.
Waldichuk, M. "Basic productivity of Trevor Channel and Alberni Inlet from chemical measurements." J. Fish. Res. Board Canada, **13** (1): 7–20. Ottawa, 1956.
Wood, E. J. F. "Considerations on productivity." ICES, J. du Cons., **21** (3): 280–3. Copenhague, 1956.

4) Benthos

4) a General

Bartel, A. H., & Davenport, D. "A technique for the investigation of chemical responses in aquatic animals." British J. Anim. Behav., **4** (3): 117–9. London, 1956.
Jones, R. F. "On the chemical composition of the brown alga *Himanthalia elongata* (L.) S. F. Gray." Biol. Bull., **110** (2): 169–78. Lancaster, Pa., 1956.
McIntyre, A. D. "The use of the trawl, grab and camera in estimating marine benthos." J. Mar. Biol. Assoc., **35** (2): 419–30. Cambridge, 1956.
Stark, I. N. "Influence of mechanised bullock dredges on food-basis of benthophagic fishes." Rybn. Khoz., **4**: 39. Moscow, 1956.
Thorson, G. "Modern aspects of marine level-bottom animal communities." J. Mar. Res., **14** (4): 387–98. New Haven, Conn., 1955.

4) b Fauna, Systematics and Development

Arnold, Z. M. "Life history and cytology of the foraminiferan *Allogromia laticollaris*." Univ. California Publ. Zool., **61** (4): 167–252. Berkeley & Los Angeles, 1955.
Atkins, D. "The post-embryonic development of British Pinnotheres (Crustacea)". Proc. Zool. Soc. London, **124** (4): 687–715. London, 1955.
Barnard, K. H. "South African parasitic Copepoda." Ann. South African Mus., **41** (5, 10): 223–312. Cape Town, 1955.
Bocquet, C. "Copépodes semi-parasites et parasites des Echinodermes de la région de Roscoff. Description de *Lichomolgus asterinae* n. sp." Bull. Soc. Zool. France, **77** (5/6): 495–504. Paris, 1953.
Bocquet, C. "Modalités et mécanismes de la spéciation chez deux crustacés marins." Bull. Soc. Zool. France, **78** (4): 276–86. Paris, 1954.
Cutress, C. E. "An interpretation of the structure and distribution of cnidae in Anthozoa." Systemat. Zool., **4** (3): 120–37. New Haven, Conn., 1955.
Davison, J. "An analysis of cell growth and metabolism in the crayfish (*Procambarus alleni*)". Biol. Bull., **110** (3): 264–73. Lancaster, Pa., 1956.
Deichmann, E. "A new record of *Athyone glasselli* (Deichmann)". Essays Natur. Sci. Allan Hancock: 179–84. Los Angeles, 1955.
Drach, P., & Forest, J. "Description et répartition des *Xantho* des mers d'Europe." Arch. Zool. Exp. Gén., **90** (1): 1–35. Paris, 1953.
Durham, J. W. "Classification of clypeasteroid echinoids." Univ. California Publ. Geol. Sci., **31** (4): 73–197. Berkeley, 1955.
Earland, A. "Some notes on foraminifera." J. Roy. Microscop. Soc., Ser. 3, **75**: 194–7. London, 1956.
Gross, J., Sokal, Z., & Rougvie, M. "Structural and chemical studies on the connective tissue of the marine sponge." J. Histochem. Cytochem., **4**: 227–46. Baltimore, 1956.
Holthuis, L. B. "The recent genera of the caridean and stenopodidean shrimps (class Crustacea, order Decapoda, supersection Natantia) with keys for their determination." Zool. Verhandel., **26**. Leiden, 1955.
Kohn, A. J. "Piscivorous gastropods of the genus *Conus*." Proc. Nation. Acad. Sci., **42** (3): 168–71. Washington, 1956.

Millard, N. A. H. "New species of Hydrozoa from South Africa." Ann. South African Mus., **41** (5, 9): 215–22. Cape Town, 1955.

Perkins, E. J. "*Microarthridion fallax*, a species of harpacticid copepod new to science from Whitstable, Kent." Ann. Mag. Natur. Hist., Ser. 12, **9** (98): 108–11. London, 1956.

Pickford, G. E. "A revision of the Octopodinae in the collections of the British Museum. I. Further light on the *Octopus rugosus* problem. II. A re-examination of the specimens of *Robsonella fontiana* in the collections of the British Museum." Bull. British Mus. (Natur. Hist.) Zool., **3** (3): 151–67. London, 1955.

Reinhard, E. G. "Some Rhizocephala found on brachyuran crabs in the West Indian region." J. Washington Acad. Sci., **45** (3): 75–80. Washington, 1955.

Rosi, H. "A report on the family Arcidae (Pelecypoda)". Allan Hancock Pacific Exped., **20** (2). Los Angeles, 1955.

Sandison, E. E. "The identification of the nauplii of some South African barnacles with notes on their life histories." Trans. Roy. Soc. South Africa, March 21, 1951.

Soot-Ryen, T. "A report on the family Mytilidae (Pelecypoda)". Allan Hancock Pacific Exped., **20** (1). Los Angeles, 1955.

Soule, J. D. "A new species of *Mysoma* from the Pacific (Entoprocta)". Essays Natur. Sci. Allan Hancock: 173–8. Los Angeles, 1955.

Tokioka, T. "Notes on some chaetognaths from the Gulf of Mexico." Bull. Mar. Sci. Gulf & Caribbean, **5** (1): 52–65. Coral Gables, Fla., 1955.

Williams, A. B. "The genus *Ogyrides* (Crustacea: Caridea) in North Carolina." J. Washington Acad. Sci., **45** (2): 56–9. Washington, 1955.

Ziesenhenne, F. "A review of the genus *Ophioderma* M. & T.". Essays Natur. Sci. Allan Hancock: 185–202. Los Angeles, 1955.

4) c Fauna, Distribution and Ecology

Amar, R. "Isopodes marines du littoral corse." Bull. Soc. Zool. France, **77** (5/6): 349–55. Paris, 1953.

Barnard, K. H. "South African Pycnogonida." Ann. South African Mus., **41** (3, 3): 81–158. Cape Town, 1956.

Bousfield, E. L. "The distribution and spawning seasons of barnacles on the Atlantic coast of Canada." Bull. Nation. Mus. Canada, **132**: 112–54. Ottawa, 1954.

Bruun, A. F. "The abyssal fauna: its ecology, distribution and origin." Nature, **177** (4520): 1105. London, 1956.

Buchanan, J. B. "Marine molluscs of the Gold Coast, West Africa." J. West African Sci. Assoc., **1** (1): 30–45. 1954.

den Dulk, A. "Ostracoden van Texel." Levende Natuur, **56** (7): 136–40. Amsterdam, 1953.

Elofson, O. "*Balanus improvisus* Darw. ny för Medelpad." Svensk Faun. Rev., **14** (2): 47–53. Stockholm, 1952.

Fauvel, P. "Contribution à la faune des annélides polychètes des côtes d'Israël." Bull. State Israel Sea Fish. Res. Stat., **10**. Haifa, 1955.

Garth, J. S. "The case for a warm-temperate marine fauna on the west coast of North America." Essays Natur. Sci. Allan Hancock: 19–28. Los Angeles, 1955.

Gerlach, S. A. "Die Nematodenfauna der Oferzonen und des Küstengrundwassers am finnischen Meerbusen." Acta Zool. Fennica, **73**: 1–32. Helsinki, 1953.

Hancock, D. A., Drinnan, R. E., & Harris, W. N. "Notes on the biology of *Sertularia argentea* L." J. Mar. Biol. Assoc., **35** (2): 307–26. Cambridge, 1956.

Hartman, O. "Endemism in the North Pacific Ocean, with emphasis on the distribution of marine annelids, and descriptions of new or little known species." Essays Natur. Sci. Allan Hancock: 39–60. Los Angeles, 1955.

Hartman, W. D. "A collection of sponges from the west coast of the Yucatan Peninsula with descriptions of two new species." Bull. Mar. Sci. Gulf & Caribbean, **5** (3): 161–89. Coral Gables, Fla., 1955.

Hertlein, L. G., & Strong, A. M. "Marine mollusks collected during the 'Askoy' expedition to Panama, Columbia, and Ecuador in 1941." Bull. American Mus. Natur. Hist., **107** (2): 159–318. New York, 1955.

Hertlein, L. G., & Strong, A. M. "Marine molluscs collected at the Galapagos Islands during the voyage of the 'Velero III', 1931–1932." Essays Natur. Sci. Allan Hancock: 111–46. Los Angeles, 1955.

Holthuis, L. B., & Gottlieb, E. "The occurrence of the American blue crab, *Callinectes sapidus* Rathbun, in Israel waters." Bull. Res. Counc. Israel, **5**b (2): 154–6. Haifa, 1955.

Hurley, D. E. "Bathypelagic and other Hyperiidea from Californian waters." Allan Hancock Found. Publ., Occas. Pap., **18**. Los Angeles, 1956.

Mattox, N. T. "Observations on the brachiopod communities near Santa Catalina Island." Essays Natur. Sci. Allan Hancock: 73–86. Los Angeles, 1955.

McNulty, J. K. "Report on additional studies of pollution in Biscayne Bay." Mar. Lab. Univ. Miami, Progr. Rep., 56–6. Coral Gables, Fla., 1956.

Miloslavskaia, N. M. "On the ecology of *Macoma baltica* (L.)." Dokl. Akad. Nauk SSSR, **101** (3). Moscow, 1955.

Moulton, J. M. "Green crabs and the redistribution of quahogs." Science, **123** (3205): 992. Lancaster, Pa., 1956.

Osburn, R. C. "The circumpolar distribution of Arctic-Alaskan Bryozoa." Essays Natur. Sci. Allan Hancock: 29–38. Los Angeles, 1955.

Perkins, E. J. "The fauna of a sand-bank in the mouth of the Dee estuary." Ann. Mag. Natur. Hist., **9** (98): 112–28. London, 1956.

Richardson, C. "Some notes on a trip to Banks Island." Arctic, **8** (3): 196–7. Ottawa, 1956.

Sjöblom, V., & Ziegelmeier, E. "Benthos." ICES, Ann. Biol., **11**. Copenhague, 1956.

Ursin, E. "Distribution and growth of the queen, *Chlamys opercularis* (Lamellibranchiata), in Danish and Faroese waters." Medd. Danmarks Fisk.- og Havunders., N. S., **1** (13). København, 1956.

Voss, G. L. "The Cephalopoda obtained by the Harvard-Havana expedition off the coast of Cuba in 1938–39." Bull. Mar. Sci. Gulf & Caribbean, **5** (2): 81–115. Coral Gables, Fla., 1955.

Westblad, E. "Marine 'alloeocoels' (Turbellaria) from North Atlantic and Mediterranean coasts. I". Arkiv Zool., **7** (6): 491–526. Stockholm, 1955.

4) d Fauna, Physiology and Behaviour

Aldrich, F. A., & Aldrich, M. M. "Studies on the reproductive functional morphology of asteroidians. I. Sex reversal in the common sea star, *Asterias forbesi* (Desor)." Notulae naturae, **276**: 1–2. Philadelphia, 1955.

Arvy, L., Gabe, M., & Scharrer, B. "Colloque international sur l'endocrinologie des invertébrés tenu à Paris les 23 et 24 juillet 1955 au laboratoire d'anatomie et histologie comparées de la Sorbonne." Ann. Sci. Natur., Zool., Ser. 2, **18** (2): Paris, 1956.

Barbard, J. L. "The wood boring habits of *Chelura terebrans* Philippi in Los Angeles harbor." Essays Natur. Sci. Allan Hannock: 87–98. Los Angeles, 1955.

Berner, L. "Biologie de *Pinnotheres pisum* Penn. (Décapode Brachyoure)." Bull. Soc. Zool. France, **77** (5/6): 344–9. Paris, 1952.

Broekhuysen, G. J. "The breeding and growth of *Hymenosoma orbiculare* Desm. (Crustacea, Brachyura)". Ann. South African Mus., **41** (5, 11): 313–43. Cape Town, 1955.

Bruun, A. F. "New light on the biology of *Spirula*, a mesopelagic cephalopod." Essays Natur. Sci. Allan Hancock: 61–72. Los Angeles, 1955.

Callame, B. "Action de la lumière sur la répartition de quelques organismes marins fixes." Trav. Centre Recherch. Etudes Océanogr., **1** (10). Paris, 1954.

Colwin, L. H., & Colwin, A. L. "The acrosome filament and sperm entry in *Thyone briareus* (Holothuria) and *Asterias*." Biol. Bull., **110** (3): 243–57. Lancaster, Pa., 1956.

Cooper, L. H. N. "The growth rate of *Chthamalus stellatus* (Poli)." J. Mar. Biol. Assoc., **35** (2): 355–62. Cambridge, 1956.

Creac'h, P. V. "Distribution of citric acid and phosphorus in the (calcareous) nonpathological deposits of various invertebrates." C. R. Soc. Biol., **149**: 1260–3. Paris, 1955.

Dodd, J. M. "Studies on the biology of limpets. III. Hermaphroditism in the three British species of *Patella*." J. Mar. Biol. Assoc., **35** (2): 327–40. Cambridge, 1956.

Drach, P. "The peduncular endocrine system, duration of intermolting period, and vitellogenesis in the decapod crustacean *Leander serratus*." C. R. Soc. Biol., **149**: 2079–83. Paris, 1955.

Eliassen, E. "The oxygen supply during ebb of *Arenicola marina* in the Danish Waddensea." Univ. Bergen, Årbok 1955, 12. Bergen, 1956.

Fingerman, M. "Phase difference in the tidal rhythms of color change of two species of fiddler crab." Biol. Bull., **110** (3): 274–90. Lancaster, Pa., 1956.

Fingerman, M., & Fitzpatrick, C. "An endocrine basis for the sexual difference in melanin dispersion in *Uca pugilator*." Biol. Bull., **110** (2): 138–43. Lancaster, Pa., 1956.

Fingerman, M., & Tinkle, D. W. "Responses of the white chromatophores of two species of prawns (Palaemonetes) to light and temperature." Biol. Bull., **110** (2): 144–52. Lancaster, Pa., 1956.

Gabe, M. "Histological details of neurosecretory cells in some lamellibranchs." C. R. Acad. Sci., **240**: 1810–2. Paris, 1955.

Ganapati, P. N., & Nagabhushanam, R. "Digestive enzymes of *Martesia striata* Linn." Current Sci., **25** (5): 156–7. Bangalore, 1956.

Hand, C. "Are corals really herbivores?" Ecology, **37** (2): 384–5. Durham, N. C. 1956.

Holmes, W. "The colour changes of cephalopods." Endeavour, **14** (54): 78–82. London, 1955.

Horridge, G. A. "The nerves and muscles of medusae. V. Double innervation in Scyphozoa." J. Exper. Biol., **33** (2): 366–83. Cambridge, 1956.

Hoyle, G., & Lowy, J. "The paradox of *Mytilus* muscle. A new interpretation." J. Exper. Biol., **33** (2): 295–310. Cambridge, 1956.

Inskip, L. W., & Cassidy, H. G. "On the amino acids of sponges." J. Mar. Res., **14** (3): 226–33. New Haven, Conn., 1955.

John, P. A. "Studies of *Melita zeylanica*, an amphipod destructive to submerged wood." Bull. Centr. Res. Inst. Univ. Travancore, Ser. C, Natur. Sci., **4** (1): 117–26. Trivandrum, 1955.

Knowles, F. "Crustacean colour change and neurosecretion." Endeavour, **14** (54): 95–104. London, 1955.

Martin, W. E. "Seasonal infections of the snail, *Cerithidea californica* Haldeman, with larval trematodes." Essays Natur. Sci. Allan Hancock: 203–10. Los Angeles, 1955.

Matsue, Y., & Sano, K. "On the sulphide deposition in the shell of baby-clam under some environmental conditions." Aquiculture, **2**: 12–9. 1955.

Nicola, M. "The distribution of carotenoids in some marine invertebrates." Pubbl. Staz. Zool. Napoli, **25** (1): 145–60. Milano, 1954.

Odum, H. T., & Odum, E. P. "Corals as producers, herbivores, carnivores, and possibly decomposers." Ecology, **37** (2): 385. Durham, N. C., 1956.

Okazaki, K. "Skeleton formation of sea urchin larvae. I. Effect of Ca concentration of the medium." Biol. Bull., **110** (3): 320–33. Lancaster, Pa., 1956.

Parameswaran, R. "Neurosecretory cells of the central nervous system of the crab, *Paratelphusa hydrodromous*". Quart. J. Microscop. Sci., **97** (1): 75–82. Oxford, 1956.

Paris, J. "Commensalisme et parasitisme chez les annélides polychètes." Vie et Milieu, **6** (4): 525–36. Paris, 1955.

Scheer, B. T., & Scheer, M. A. R. "The hormonal control of metabolism in crustaceans. VII. Moulting and color change in the prawn *Leander serratus*." Pubbl. Staz. Zool. Napoli, **25** (3): 397–418. Milano, 1954.

Scheer, B. T., & Scheer, M. A. R. "The hormonal control of metabolism in crustaceans. VIII. Oxygen consumption in *Leander serratus*." Pubbl. Staz. Zool. Napoli, **25** (3): 419–26. Milano, 1954.

Sharman, M. "Note on *Capulus ungaricus* (L.)." J. Mar. Biol. Assoc., **35** (2): 445–50. Cambridge, 1956.

Yoshida, M. "On the breeding character of the shrimp, *Leander serrifer*, parasitized by bopyrids." Annot. Zool. Japonenses, **25** (3): 362–5. Tokyo, 1952.

Zuckerkandl, E. "Variations during the intermolt cycle in the protein fractions of the hemolymph of *Maia squinado* as separated by electrophoresis." C. R. Soc. Biol., **150**: 39–41. Paris, 1956.

4) e Flora

Atkins, D. "*Pythium thalassium* sp. nov. infecting the egg-mass of the pea-crab, *Pinnotheres pisum*." Trans. British Mycol. Soc., **38** (1): 31–46. Worcester, 1955.

von Brandt, A. "Algenverwertung an der bretonischen Küste." Die Fischwirtschaft, **8** (7): 168. Bremerhaven, 1956.

Dawson, E. Y. "A preliminary working key to the living species of *Dermatolithon*." Essays Natur. Sci. Allan Hancock: 271–8. Los Angeles, 1955.

Duncan, W. A. M., Manners, D. J., & Ross, A. G. "Enzyme systems in marine algae. The carbohydrase activities of unfractionated extracts of *Cladophora rupestris*, *Laminaria digitata*, *Rhodymenia palmata* and *Ulva lactuca*". Biochem. J., **63** (1): 44–51. Cambridge, 1956.

Ercegovic, A. "Contribution à la connaissance des ectocarpes (*Ectocarpus*) de l'Adriatique moyenne." Acta Adriatica, **7** (5). Split, 1955.

Ercegovic, A. "Contribution à la connaissance des Pheophycées de l'Adriatique moyenne." Acta Adriatica, **7** (6). Split, 1955.

Foster, W. S. "Sea moss, (*Chondrus crispus*), survey Pemaquid Point to Owls Head." Dept. Sea & Shore, Gen. Bull., **5**. Augusta, Maine, 1955.

Habekost, R. C., Fraser, I. M., & Halstead, B. W. "Observations on toxic marine algae." J. Washington Acad. Sci., **45** (4): 101–3. Washington, 1955.

Hashimoto, Y. "Vitamin B_{12} in marine and freshwater algae." J. Vitaminol., **1** (1): 49–54. Osaka, 1954.

Jaffe, L. "Effect of polarized light on polarity of *Fucus*." Science, **123** (3207): 1081–2. Lancaster, Pa., 1956.

Pineda, M. D. G., & Montequi, D. "Acerca de la sustancia anticoagulante de las algas rojas." Bol. Inst. Español Oceanogr., **72**. Madrid, 1955.

Rayss, T. "Les algues marines des côtes paléstiniennes. I. Chlorophyceae." Bull. State Israel Sea Fish Res. Stat., **9**. Haifa, 1955.

Scagel, R. F. "Introduction of a Japanese alga, *Sargassum muticum*, into the north-east Pacific." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 49–58. Washington, 1956.

Smith, D. G., & Young, E. G. "The combined amino acids in several species of marine algae." J. Biol. Chem., **217** (2): 845–53. Baltimore, 1955.

Susuki, N. "Studies on the manufacture of algin from brown algae." Mem. Fac. Fish. Hokkaido Univ., **3** (2): 93–158. Hakodate, 1955.

Taylor, W. R. "Marine algal flora of the Caribbean and its extension into neighbouring seas." Essays Natur. Sci. Allan Hancock: 259–70. Los Angeles, 1955.

Vishniac, H. S. "Marine mycology." Trans. New York Acad. Sci., **17** (4): 352–60. New York, 1955.

Walker, F. T. "Periodicity of the Laminariaceae around Scotland." Nature, **177** (4522): 1246. London, 1956.

Walton, W. R. "Ecology of living benthonic foraminifera, Todos Santos Bay, Baja California." J. Paleontol., **29** (6): 952–1018. Tulsa, Okl., 1955.

4) f Bacteria

Burkholder, P. R., & Burkholder, L. M. "Microbiological assay of vitamin B_{12} in marine solids." Science, **123** (3207): 1071. Lancaster, Pa., 1956.

Courinton, D. P., & Goodwin, T. W. "A survey of the pigments of a number of chromogenic marine bacteria with special reference to the carotenoids." J. Bacteriol., **70** (5): 568–71. Baltimore, 1955.

Cviic, V. "Distribution of bacteria in the waters of the mid Adriatic Sea." M. V. "Hvar" Cruises, Res. Fish. Biol., **4** (1). Split, 1955.

Morita, R. Y., & Zobell, C. E. "Occurrence of bacteria in pelagic sediments collected during the Mid-Pacific Expedition." Deep-Sea Res., **3** (1): 66–73. London & New York, 1955.

Sreenivasan, A. "New species of marine bacteria tolerating high concentrations of copper." Current Sci., **25** (3): 92. Bangalore, 1956.

5) Fishing

5) a Statistical Returns

ANON. "Report on the sea and inland fisheries for the year 1954." Dept. Agric., Fish. Branch. Dublin, 1955.

ANON. "Report on the British fishing industry. Distant water trawlers 1955." British Trawlers' Federation. Hull, Grimsby, & Fleetwood, 1956.

ANON. "Statistiek van de visserij 1955." Centr. Bur. Statist. Utrecht, 1956.

ANON. "United States and Alaska fisheries production, 1955." Commerc. Fish. Rev., **18**: 36–7. Washington, 1956.

ANON. "Report on the sea and inland fisheries for the year 1955, incorporating statistics of the capture of salmon, sea trout, and eels." Dept. Agric. Eire, Fish. Branch. Dublin, 1956.

ANON. "Statistical Bulletin, Vol. 4, for year 1954." ICNAF. Halifax, 1956.

ANON. "El año pesquero Español a traves de la estadistica." Industr. Pesqu., **30** (697–8): 94–9. Vigo, 1956.

ANON. "Rapport annuel sur l'évolution de la flotte de pêche en 1955." Min. Commun. Admin. Mar. Belgique, 1956.

ANON. "La production de l'industrie de la pêche a atteint 427.000 tonnes en 1955." Pêche Mar., **937**: 149–53. Paris, 1956.

ANON. "Scottish sea fisheries statistical tables 1955." Scottish Home Dept. Edinburgh, 1956.

ANON. "1955 commercial fishing statistics." State of Washington, Dept. Fish. Washington, 1956.

DROST, H. S. "Wedloop van motorkotters en overige kleine vaartuigen." Visserij-Nieuws, **8** (8): 132–8. 's-Gravenhage, 1956.

FRIIS, K. "Fisket ved Vest-Grønland 1955." Fiskets Gang, 24: 342–8. Bergen, 1956.

SMITH, H. S. "Fisheries statistics of Oregon 1950–1953." Contrib. Fish Commiss. Oregon, **22**. Portland, 1956.

5) b Vessels

ANON. "Technical report of fishing boat. 5". Fish. Boat Lab., Product. Div. & Forestry. Tokyo, 1954.

ANON. "Technical report of fishing boat. 7." Fish. Boat Lab., Product. Div. & Forestry. Tokyo, 1956.

GUEROULT, E. R. "L'évolution des thoniers." Pêche Mar., **940**: 289–92. Paris, 1956.

MALIAKIN, I. I. "Experimental operation of small seiner 'Kamchatsk'". Rybn. Khoz., 3: 60. Moscow, 1956.

5) c Gear

ANADON, E. "La selectividad del boliche." Invest. Pesqu., **3**: 91–8. Barcelona, 1956.

ANON. "Nylon gill nets prove successful – Thailand." Commerc. Fish. Rev., **17** (11): 69. Washington, 1955.

ANON. "Trawling for herring: a note by the Herring Industry Board." Edinburgh, 1956.

ANON. "Mesure de la réflexion des ultrasons." Pêche Mar., **939**: 262–3. Paris, 1956.

ANON. "Crab potter has luck with use of zinc anodes." Southern Fisherman, **16**: 163 & 165. 1956.

ATTON, F. M. "Relative effectiveness of nylon and cotton gill nets." Canadian Fish Cult., **17**: 18–26. Ottawa, 1955.

AZHAZHA, V. G. "Improving exploitation of hydro-acoustical methods." Rybn. Khoz., 4: 6. Moscow, 1956.

BALLS, R. "Using Swedish bottom herring trawl." World Fishing, **5** (5): 32–6. London, 1956.

BARRACLOUGH, W. E. "A new mid-water trawl for herring." Bull. Fish. Res. Board Canada, **104**. Ottawa, 1956.

VON BRANDT, A. "Um die Maschengrösse bei Schleppnetzen." Die Fischwirtschaft, **8** (4): 87–8. Bremerhaven, 1956.

VON BRANDT, A. "Die bretonische Reusenfischerei." Die Fischwirtschaft, **8** (4): 97–8. Bremerhaven, 1956.

von Brandt, A. "Fischerei zu Fuss." Die Fischwirtschaft, **8** (5–6): 132–3. Bremerhaven, 1956.

von Brandt, A. "Zur Maschenmessung bei Schleppnetzen." Protok. Fischereitechn., **4** (17): 45–69. Hamburg, 1956.

Bullis, H. R., & Captiva, F. J. "US method of tuna longlining." Fish. Newsletter, **15** (4): 7&9. Sydney, 1956.

Cabo, F. L. "Nueva luz para pesca con cerco." Industr. Pesqu., **30** (697–698): 85. Vigo, 1956.

Glanville, A. "Richest fishing in the world. Californian catching methods." World Fishing, **5** (6): 42–6. London, 1956.

Glude, J., Spear, H., & Wallace, D. "The hydraulic clam rake, a new method of gathering seed clams." Proc. Nation .Shellf. Assoc. 1952: 163–6. Washington, 1953.

Good, C. M. "Asdic in the fishing industry." World Fishing, **5** (3): 26–8, and **5** (4): 21–2. London, 1956.

Gulland, J. A. "On the selection of hake and whiting by the mesh of trawls." ICES, J. du Cons., **21** (3): 296–309. Copenhague, 1956.

Jones, R. "A discussion of some limitations of the trawl as a sambling instrument." ICES, R. et P.-V., **140** (1): 44–7. Copenhague, 1956.

Klust, G. "Längenveränderungen von Netzgarnen durch Wässerung." Protok. Fischereitechn., **4** (17): 70–83. Hamburg, 1956.

Lang, O. "50 years of change in German herring fishing." World Fishing, **5** (5): 46–8. London, 1956.

Margetts, A. R. "The sampling of demersal fish stocks by trawls and seines." ICES, R. et P.-V., **140** (1): 40–3. Copenhague, 1956.

Miura, T. "Mechanical studies of fishing net materials. IV. A method of measuring the diameter of a netting cord." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 208–12. Hakodate, 1956.

Miura, T. "Mechanical studies of fishing net materials. V. Relations between some designations on the fineness of Manilla twines." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 212–5. Hakodate, 1956.

Miyamoto, H., & Takayama, H. "Durability of netting threads against self-friction." Bull. Japanese Soc. Sci. Fish., **21** (3): 141–53. Tokyo, 1955.

O'Grady, A. "Australian prawn trials." World Fishing, **5** (5): 54–6. London, 1956.

Parrish, B. B., Jones, R., & Pope, J. A. "A comparison of mesh-measuring methods." ICES, J. du Cons., **21** (3): 310–8. Copenhague, 1956.

Samaryanov, A. N. "Purse seine using two purse lines. Russian technique for preventing escape from seine." World Fishing, **5** (5): 37–40. London, 1956.

Schärfe, J. "Fangmethoden und Fanggeräte beim Rochenfang in Deutschland." Protok. Fischereitechn., **4** (17): 32–40. Hamburg, 1956.

Schärfe, J. "Fernmeldender Tiefenmesser für Schwimmschleppnetze." Die Fischwirtschaft, **8** (5/6): 130. Bremerhaven, 1956.

Scofield, W. L. "Trolling gear in California." California Fish & Game, Fish. Bull., **103**. Sacramento, 1956.

Shishkova, E. V. "Damping of ultrasonic noise in fish shoals." Rybn. Khoz., 3: 73. Moscow, 1956.

Starrett, W. C., & Barnickol, P. G. "Efficiency and selectivity of commercial fishing devices used on the Mississippi River." Bull. Illinois Natur. Hist. Surv., **26** (4): 325–66. Urbana, 1955.

Timmermans, J. A. "La pêche électrique en eau douce." Trav. Stat. Rech. Groenendaal, Ser. D, **15**: 1–31. Jette, Belgium, 1954.

Torban, S. S. "New method of mechanisation of fishing by purse-nets." Rybn. Khoz., 3: 66. Moscow, 1956.

Wide, E. "Elfiske 2. Några förslag till lösning av de elektrotekniska problemen vid konstruktion av elfiskeaggregat." Södra Sveriges Fiskerifören. 1906–1955: 106–11. Lund, 1956.

Wide, E. "Elfiske 3. Enkelt aggregat för elfiske." Södra Sveriges Fiskerifören. 1906–1955: 112–13. Lund, 1956.

Wide, E. "Elfiske 4. Redogörelse över några sötvattensfiskars reaktioner i elfältet vid elfiske." Södra Sveriges Fiskerifören. 1906–1955: 113–8. Lund, 1956.

5) d Grounds and Fishing Surveys

Anon. "Fisheries agreement between the government of the United Kingdom of Great Britain and Northern Ireland and the government of the Union of Soviet Socialistic Republics (together with minute to Art. 1 of the agreement and exchange of notes on territorial waters). Moscow, May 25, 1956." HMSO, Cmd. 9778. London, 1956.

Burdon, T. W. "A report on the fishing industry of Malta." 79 pp. Government Printing Off., Malta, 1956.

Postel, E. "La pêche maritime en Tunisie." Pêche Mar., **938**: 199–201. Paris, 1956.

5) e Technology

Castell, C. H., & Greenough, M. F. "Spoilage of fish in the vessels at sea 4. Effect of removal of gills on rate of spoilage." J. Fish. Res. Board Canada, **13** (3): 291–6. Ottawa, 1956.

Ingram, M., Barnes, E. M., & Shewan, J. M. "Problems in the use of antibiotics for preserving meat and fish." Food Sci. Abstr., **28** (2): 121–36. London, 1956.

Koster, J. T. "Sur la végétation d'algues marines de la Zélande." Blumea, **7** (3): 558–69. Leiden, 1954.

MacCallum, W. A. "Fish handling and hold construction in Canadian North Atlantic trawlers." Bull. Fish. Res. Board Canada, 103. Ottawa, 1955.

Wort, D. J. "The seasonal variation in chemical composition of *Macrocystis integrifolia* and *Nereocystis leutkeana* in British Columbia costal waters." Canadian J. Bot., **33** (4): 323–40. Ottawa, 1955.

6) Fish

6) a Cod

Dannevig, E. H. "Chemical composition of the zones in cod otoliths." ICES, J. du Cons., **21** (2): 156–9. Copenhague, 1956.

Ellis, G. H. "Observations on the shoaling behaviour of cod (*Gadus callarias*) in deep water relative to daylight". J. Mar. Biol. Assoc., **35** (2): 415–7. Cambridge, 1956.

Hansen, P. M., Joensen, J. S., Jónsson, J., Lundbeck, J., Meyer, A., & Rollefsen, G. "Cod". ICES, Ann. Biol., **11**. Copenhague, 1956.

Kramer, G. "Über Proportionsänderungen im Laufe des Wachstums nach Eintritt der Geschlechtsreife beim Dorsch (*Gadus morrhua* L.)". Zool. Jahrb., Abt. Allg. Zool. Physiol. Tiere, **65** (1): 1–8. Jena, 1954.

McKenzie, R. A. "Atlantic cod tagging off the Southern Canadian mainland." Bull. Fish. Res. Board Canada, **105**. Ottawa, 1956.

McCracken, F. D. "Cod and haddock tagging off Lockeport, N. S." Fish. Res. Board Canada, Progr. Rep. Atlantic Coast Stat., **64**: 10–5. St. Andrews, 1956.

Pope, J. A. "An outline of sampling techniques." ICES, R. et P.-V., **140** (1): 11–20. Copenhague, 1956.

Rollefsen, G. "The arctic cod." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 115–7. New York, 1956.

Sætersdal, G. "A comparison of brood-strength fluctuations of the cod in the immature and mature parts of the Arcto-Norwegian cod population." ICES, R. et P.-V., **140** (1): 84–6. Copenhague, 1956.

Scott, D. M. "On the specific identity of the larval *Porrocaecum* (Nematoda) in Atlantic cod." J. Fish. Res. Board Canada, **13** (3): 343–56. Ottawa, 1956.

6) b Haddock

Jones, R., Lundbeck, J., Main, W., & Sætersdal, G. "Haddock". ICES, Ann. Biol., **11**. Copenhague, 1956.

Lovern, J. A. "The lipids of fish. I. The triglycerides and cholesterol esters of haddock flesh." Biochem. J., **63** (3): 373–80. Cambridge, 1956.

McCracken, F. D. "Cod and haddock tagging off Lockeport, N. S." Fish. Res. Board Canada, Progr. Rep. Atlantic Coast Stat., **64**: 10–5. St. Andrews, 1956.

6) c Hake

Andreu, B. "Observaciónes sobre el ovario de merluza (*Merluccius merluccius* L.) y caracteristicas del mecanismo de la puesta." Invest. Pesqu., **4**: 49–66. Barcelona, 1956.

Gulland, J. A. "On the selection of hake and whiting by the mesh of trawls." ICES, J. du Cons., **21** (3): 296–309. Copenhague, 1956.

Maurin, C. "Hake". ICES, Ann. Biol., **11**. Copenhague, 1956.

McKenzie, R. A. "Silver hake, *Merluccius billinearis*, in the Gulf of St. Lawrence." Copeia, 2: 111. Baltimore, 1956.

6) d Plaice

Bagge, O., Bertelsen, E., Gulland, J. A., Jensen, Aa. J. C., Kotthaus, A., Sigurdsson, A., Ursin, E., & Ziegelmeier, E. "Plaice". ICES, Ann. Biol., **11**. Copenhague, 1956.

Kändler, R. "Response of the plaice to environmental factors." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 102–8. New York, 1956.

Kotthaus, A. "Die deutschen Schollenuntersuchungen von 1948–1954." Ber. Deutschen Wiss. Komm. Meeresf., N. F., **14** (2): 83–108. Stuttgart, 1956.

Molander, A. R. "Some marginal notes on the question of the growth and size of plaice and flounder in the southern Baltic." Inst. Mar. Res. Lysekil, Ser. Biol., **4**: 1–18. Göteborg, 1955.

Perkins, N. E. "Light intensity and pigmentation." Aquarist, **21** (2): 22–3. London, 1956.

6) e Sole

van Cleve, R., & Pruter, A. T. "Problems of sampling a Puget Sound population of English sole, *Parophrys vetulus*." ICES, R. et P.-V., **140** (1): 87–93. Copenhague, 1956.

Palmen, A. T. "A comparison of otoliths and interopercular bones as age indicators of English sole." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 5–20. Washington, 1956.

Westrheim, S. J. "Size composition, growth, and seasonal abundance of juvenile English sole (*Parophrys vetulus*) in Yaquina Bay." Fish Comm. Oregon, Res. Briefs, **6** (2): 4–9. Portland, 1955.

6) f Halibut

Dunlop, H. A. "Management of the halibut fishery of the north-eastern Pacific Ocean and Bering Sea." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 222–42. New York, 1956.

McIntyre, A. D. "Halibut line fishery at Faroe: 'improvement' forecast for 1957." World Fishing, **5** (5): 50–2. London, 1956.

6) g Other Marine Demersal Species

Bagge, O., Bohl, H., Fridriksson, A., Jensen, Aa. J. C., Jensen, J. P., Knudsen, J., Messtorff, J., Meyer, A., Olsen, S., & Østvedt, O. J. "Various demersal species." ICES, Ann. Biol., **11**. Copenhague, 1956.

Barraclough, W. E. "The occurrence of the two-pronged hatchetfish, *Argyropelecus sladini*, in British Columbia." Copeia, 2: 109–10. Baltimore, 1956.

Berlin, L. B., & Schalumovich, V. N. "Histological examination of epidermis in *Petromyzon fluviatilis* with the aid of luminescence, ultra-violet and anoptral microscopy." Dokl. Akad. Nauk SSSR, **107** (6): 891. Moscow, 1956.

Böhlke, J., & Cliff, F. S. "A discussion of the deep-sea eel genus *Avocettinops* with notes on a newly discovered specimen." Copeia, 2: 95–9. Baltimore, 1956.

Breder, C. M. "Special features of visibility reduction in flat fishes." Zoologica, **40** (8): 91–8. New York, 1955.

Eaton, T. H., *et al.* "Structure and relationships of the anglerfish, *Lophius americanus*." J. Elisha Mitchell Sci. Soc., **70** (2): 205–18. Chapel Hill, N. Carolina, 1954.

Erkkila, L. F., Smith, B. R., & McLain, A. L. "Sea lamprey control on the Great Lakes 1953 and 1954." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., 175. Washington, 1956.

Gulland, J. A. "On the selection of hake and whiting by the mesh of trawls." ICES, J. du Cons., **21** (3): 296–309. Copenhague, 1956.

Kanoh, Y. "On the buoyancy of the egg of Alaska pollack, *Theragra chalcogramma*." Japanese J. Ichthyol., **3** (6): 238–46. Tokyo, 1954.

Kleerekoper, H., & Sibakin, K. "An investigation of the electrical 'spike' potentials produced by the sea lamprey (*Petromyzon marinus*) in the water surrounding the head region." J. Fish. Res. Board Canada, **13** (3): 375–83. Ottawa, 1956.

Kopytov, S. D. "Prolonging the period of capture of the sea perch in the Murmansk basin." Rybn. Khoz., 3: 15. Moscow, 1956.

Kristensen, I. "Twee rode zeedonderpadden (*Cottus scorpius* L.)". Levende Natuur, **56** (2): 39. Amsterdam, 1953.

Kurata, H. "On the rearing of larvae of the flatfish, *Liopsetta obscura*, in small aquaria." Bull. Hokkaido Reg. Fish. Res. Lab., **13**: 20–9. Hokkaido, 1956.

Larrañeta, M. G., & Rodriguez-Roda, J. "Contribución al conocimiento de la pesqueria del salmonete de fango (*Mullus barbatus* L.) de las costas de Castellon." Invest. Pesqu., **3**: 45–68. Barcelona, 1956.

Lowenstein, O. "Pressure receptors in the fins of the dogfish *Scylliorhinus canicula*." J. Exper. Biol., **33** (2): 417–21. Cambridge, 1956.

Macomber, R. D. "Pufferfish toxin." J. Washington Acad. Sci., **46**: 85. Washington, 1956.

Miwa, K., & Kinoshita, E. "A survey of the vitamins A and D in the liver oil of Alaska pollack (*Theragra chalcogramma*) in Hokkaido." Bull. Hokkaido Reg. Fish. Res. Lab., **13**: 66–76. Hokkaido, 1956.

Planas, A., & Vives, F. "Contribución al estudio de la solleta (*Citharus linguatula* Günth.) del Mediterraneo occidentale (Sectores de Vinaroz e Islas Columbretes)." Invest. Pesqu., **3**: 107–30. Barcelona, 1956.

Poole, D. F. G. "The fine structure of the scales and teeth of *Raia clavata*." Quart. J. Microscop. Sci., **97** (1): 99–107. Oxford, 1956.

Schreiner, K. E. "Studies on the gonad of *Myxine glutinose* L." Univ. Bergen, Årbok 1955, 8. Bergen, 1956.

Talbot, F. H. "Notes on the biology of the white stumpnose, *Rhabdosargus globiceps* (Cuvier), and on the fish fauna of the Klein River estuary." Trans. Roy. Soc. South Africa, **34** (3): 387–407. Cape Town, 1955.

Tavolga, W. N. "Pre-spawning behaviour in the gobiid fish, *Bathygobius soporator*." Behaviour, **9** (1): 53–74. Leiden, 1956.

6) h Herring

Baxter, I. G., Bertelsen, E., Buchan, J. D., Devold, F., Dragesund, O., Fridriksson, A., Gilis, C., Hannerz, L., Hempel, G., Hodgson, W. C., Jensen, Aa. J. C., McPherson, G., Parrish, B. B., Popp Madsen, K., Saville, A., Täning, Å. V., de Veen, J., Wood, R. J., & Zijlstra, J. J. "Herring". ICES, Ann. Biol., **11**. Copenhague, 1956.

Cushing, D. H. "Phytoplankton and the herring: Part V." Fish. Invest., Ser. 2, **20** (4). London, 1956.

Cushing, D. H., & Burd, A. C. "Recruitment and maturity of the East Anglian herring." Nature, **178** (4524): 86. London, 1956.

Djalepov, A. K. "Obstacles to development of the drift-net fishery in the open parts of the Barents Sea." Rybn. Khoz., 3: 41. Moscow, 1956.

Einarsson, H. "Observations on plankton, temperature and the distribution of herring, made from the research vessel 'Ægir' during the summer of 1955." Fjölrit Fiskideildar, **7**. Reykjavik, 1956.

Gilis, C. "Méthode d'échantillonage de harengs en Belgique." ICES, R. et P.-V., **140** (1): 101. Copenhague, 1956.

Miller, D. J., & Schmidtke, J. "Report on the distribution and abundance of Pacific herring (*Clupea pallasi*) along the coast of central and southern California." California Fish & Game, **42** (3): 163–87. Sacramento, 1956.

Parrish, B. B. "The forecast for the Scottish North Sea herring fisheries." Scottish Fish. Bull., **5**: 2–12. Edinburgh, 1956.

Parrish, B. B., & McPherson, G. "Sampling problems in fish population studies, with special reference to North Sea herring investigations." ICES, R. et P.-V., **140** (1): 48–57. Copenhague, 1956.

Studenetskii, N. I. "The work of the N. Atlantic herring expedition." Rybn. Khoz., 3: 10. Moscow, 1956.

Tibbo, S. N. "Explorations for herring in the Newfoundland area." Trade News, **8** (11): 3. Ottawa, 1956.

de Veen, J. "Notities over de bliek." Visserij-Nieuws, **8** (11): 196–8. 's-Gravenhage, 1956.

Wulff, A. "Über das Eingeweidefett ('Ister') des Herings." ICES, J. du Cons., **21** (2): 171–4. Copenhague, 1956.

6) i Pilchard

Anon. "Rapid growth of South Africa's pilchard industry." Fishing News, **2254**: 10. London, 1956.

Aurich, H., Cuesta, J., Dannevig, G., Fernandez, R., Letaconnoux, R., Navarro, F., Pinto, J. S. *et al.*, & Ramalho, A. M. "Pilchard." ICES, Ann. Biol., **11**. Copenhague, 1956.

Furnestin, J. "The Atlantic sardine." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 91–4. New York, 1956.

Gamulin, T. "Migrations of the Adriatic sardine in relation to zooplankton." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 338–40. New York, 1956.

Gamulin, T., & Hure, J. "Contribution à la connaissance de l'écologie de la ponte de la sardine (*Sardina pilchardus* Walb.) dans l'Adriatique." Acta Adriatica, **7** (8). Split, 1955.

Jackson, W. T. "A sardine run". African Wild Life, **9** (2): 105–7. Johannesburg, 1955.

Muzinic, R. "Quelques observations sur la sardine, l'anchois et le maquereau des captures au chalut dans l'Adriatique." Acta Adriatica, **7** (13). Split, 1956.

Muzinic, R. "Some observations on the habits of the sardine." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 95–6. New York, 1956.

Vucetic, T. "Contribution à la connaissance des habitudes alimentaires de la sardine adulte (*Sardina pilchardus* Walb.) dans l'Adriatique moyenne." Acta Adriatica, **7** (11). Split, 1955.

Zupanovic, S. "A statistical contribution to the study in ecology of sardine (*Sardina pilchardus* Walb.) in the central Adriatic." Acta Adriatica, **7** (10). Split, 1955.

6) j Tunny and Mackerel

Anon. "Parasitologische Untersuchungen am Roten Thunfisch in der Nordsee." Wiss. Inform. Fischereipraxis, **3** (3): 58. Bremerhaven, 1956.

Bagge, O., Kändler, R., Pinto, J. S., Ramalho, A. M., & Revheim, A. "Tunny and mackerel." ICES, Ann. Biol., **11**. Copenhague, 1956.

Bellón, L. "Historia natural del atún, *Thunnus thynnus* (L.). Ensayo de sintesis (precidida de la necrologia del autor)". Bol. Inst. Español. Oceanogr., **67**: 1–88. Madrid, 1954.

Fitch, J. E. "Age composition of the Southern California catch of Pacific mackerel for the 1954–55 season." California Fish & Game, **42** (2): 143–8. Sacramento, 1956.

Jensen, Aa. J. C. "Reactions of mackerel to environmental factors." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 97–101. New York, 1956.

Muzinic, R. "Quelques observations sur la sardine, l'anchois et le maquereau des captures au chalut dans l'Adriatique." Acta Adriatica, **7** (13). Split, 1956.

Postel, E. "La croissance du thon à nageoires jaunes, *Neothunnus albacora* (Lowe) dans l'Atlantique tropical." Bull. Soc. Zool. France, **79** (2/3): 85–90. Paris, 1954.

Royce, W. F. "A statement on the ecology of tunas." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 118–21. New York, 1956.

Sano, O. "On the development of brain pattern of the Atka mackerel *Pleurogrammus azonus* Jordan et Metz. (1)." Bull. Hokkaido Reg. Fish. Res. Lab., **13**: 30–9. Hokkaido, 1956.

Schaefer, M. B. "Scientific investigation of the tropical tuna resources of the eastern Pacific." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 194–221. New York, 1956.

Serventy, D. L. "The southern bluefin tuna, *Thunnus thynnus maccoyii* (Castelnau), in Australian waters." Australian J. Mar. Freshw. Res., **7** (1): 1–43. Melbourne, 1956.

Serventy, D. L. "Additional observations on the biology of the northern bluefin tuna, *Kishinoella tonggol* (Bleeker), in Australia." Australian J. Mar. Freshw. Res., **7** (1): 44–63. Melbourne, 1956.

de Sylva, D. P. "The osteology and phylogenetic relationships of the blackfin tuna, *Thunnus atlanticus* (Lesson)." Bull. Mar. Sci. Gulf & Caribbean, **5** (1): 1–41. Coral Gables, Fla., 1955.

Vijayaraghavan, P. "Life history and feeding habits of the spotted seer *Scomberomorus guttatus* (Bloch & Schneider)." Indian J. Fish., **2** (2): 360–72. Bangalore, 1955.

6) k Other Marine Pelagic Species

Arté, P. "Observaciónes biológicas sobre el espadin (*Clupea sprattus* L.) del NW de España (Ria de Vigo)." Invest. Pesqu., **3**: 21–44. Barcelona, 1956.

Baudrimont, A. "Structure of the pulmonary veins and action of the pulmonary circulation in the common dolphin." Bull. Microscop. Appl., Ser. 2, **5**: 57–76. Paris, 1955.

de Buen, F. "El estudio de la edad y el crecimiento en peces, viviendo en medios oceanicos diferentes, y especialmente en la anchoveta o chicora (*Engraulis ringens*)." Bol. Cient., **2**: 41–7. Lima, 1955.

Gerking, S. D. "Influence of rate of feeding on body composition and protein metabolism of bluegill sunfish." Physiol. Zool., **28**: 267–82. Chicago, 1955.

Gerking, S. D. "Endogenous nitrogen excretion of bluegill sunfish." Physiol. Zool., **28**: 283–9. Chicago, 1955.

LaMonte, F. R. "A review and revision of the marlin, genus *Makaira*." Bull. American Mus. Natur. Hist., **107** (3): 319–58. New York, 1955.

Lunz, G. R. "Menhaden industry needs developing." South Carolina Wildl., Spring 1954 Edit. Columbia, 1954.

Muzinic, R. "Quelques observations sur la sardine, l'anchois et le maquereau des captures au chalut dans l'Adriatique." Acta Adriatica, **7** (13). Split, 1956.

Rae, B. B. "The basking shark fishery on the West of Scotland." Scottish Fish. Bull., **5**: 13–4. Edinburgh, 1956.

Smith, J. L. B. "A marlin in Angola, with a note on *Makaira herschelii* (Gray), 1838." Nature, **177** (4522): 1246. London, 1956.

Talbot, G. B. "Factors associated with fluctuations in abundance of Hudson River shad." US Dept. Inter., Fish & Wildl. Serv., Fish. Bull., **56** (101): Washington, 1954.

Vives, F., & Suau, P. "El espadin del Mediterraneo occidental (*Clupea sprattus* var. *phalerica* Risso)." Invest. Pesqu., **4**: 3–24. Barcelona, 1956.

Whitcutt, J. M., & Sutton, D. A. "South African pilchard oil. 5. The isolation and structure of an eicosapentaenoic acid from South African pilchard oil." Biochem. J., **63** (3): 469–75. Cambridge, 1956.

6) l Salmon and Trout

Black, E. C. "Appearance of lactic acid in the blood of Kamloops and lake trout following live transportation." Canadian Fish Cult., **18**: 20–7. Ottawa, 1956.

Corbett, M. B. "Occurrence of two species of *Crepidostomum* in brown trout (*Salmo trutta* L.) from north-east Ireland with special reference to *Crepidostomum metoecus* Braun 1900." Parasitol., **45**: 186–8. Cambridge, 1955.

Ellis, C. H. "Tests on hauling as a means of reducing downstream migrant salmon mortalities on the Columbia River." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 46–8. Washington, 1956.

Elling, C. H., & Macy, P. T. "Pink salmon tagging experiments in Icy Strait and Upper Chatham Strait 1950." US Dept. Inter., Fish & Wildl. Serv., Fish. Bull., **56** (100). Washington, 1955.

Fontaine, M., Leloup, J., & Olivereau, M. "La fonction thyroïdienne du jeune saumon, *Salmo salar* L. (parr et smolt) et son intervention possible dans la migration d'avalaison." Arch. Sci. Physiol., **6** (2): 83–104. Paris, 1952.

Guallart Elias, E. "Una lección de piscicultura. Manera de lograr la eficacia de las operaciones de diseminación de crias de salmónidos en los rios." Montes, **10** (58): 231–5. Madrid, 1954.

Henry, K. A. "River recoveries of marked silver salmon of the 1949 brood released from the Nehalem River hatchery." Fish Commiss. Oregon, Res. Briefs, **6** (2): 25–31. Portland, 1955.

Hoar, W. S. "The behaviour of migrating pink and chum salmon fry." J. Fish. Res. Board Canada, **13** (3): 309–25. Ottawa, 1956.

Hublou, W. F., *et al.* "Fifth progress report on salmon diet experiments." Fish. Commiss. Oregon, Res. Briefs, **6** (2): 10–4. Portland, 1955.

Jensen, H. M. "Migratory habits of pink salmon in the Tacoma Narrows area of Puget Sound." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 21–4. Washington, 1956.

Jensen, H. M. "Recoveries of immature chum salmon tagged in southern Puget Sound." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 32. Washington, 1956.

Kändler, R., & Knudsen, J. "Salmon". ICES, Ann. Biol., **11**. Copenhague, 1956.

Kubo, T. "Changes of some characteristics of blood of smolt of *Oncorhynchus masou* during seaward migration." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 201–7. Hakodate, 1955.

Kubo, T. "Peculiarity of population of chum salmon in the Shiriuchi River in respect to the vertebral count." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 266–79. Hakodate, 1955.

Kynaston, T. P. "Growth changes in the diameter of peripheral nerve fibres in fishes." J. Anat., **90** (1): 5–14. London, 1956.

Kyte, R. M. "Constituent fatty acids of salmon egg fat." J. American Oil Chem. Soc., **33**: 146–9. Chicago, 1956.

Laakso, M., & Cope, O. B. "Age determination in Yellowstone cutthroat trout by the scale method." J. Wildl. Managem., **20** (2): 138–53. Menasha, Wis., 1956.

Lal, M. B. "Occurrence of a new parasite (*Trematode metacercaria*) in the eyes of Scottish trout." Proc. Roy. Phys. Soc. Edinburgh, **24** (1): 1–3. Edinburgh, 1955.

McCully, H. "An undescribed type of migration in king salmon, *Oncorhynchus tshawytscha* (Walbaum)." California Fish & Game, **42** (3): 189–98. Sacramento, 1956.

Moiseev, P. A. "Fishery for salmon in the open sea in the north part of the Pacific Ocean." Rybn. Khoz., 4: 54. Moscow, 1956.

Moore, H. L., & Newman, H. W. "Effects of sound waves on young salmon." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., **172**. Washington, 1956.

Nelson, P. R., & Abegglen, C. E. "Survival and spawning of gill-net-marked red salmon." US Dept. Inter., Fish & Wildl. Serv., Res. Rep., **40**. Washington, 1955.

Nomura, M. "On the taxonomic characters in the mouth cavity of salmonoid fishes. II. Pacific salmons." Japanese J. Ichthyol., **3** (6): 232–7. Tokyo, 1954.

Pulford, E. F. "Escapement of spring chinook salmon and steelhead over Willamette Falls in 1954." Fish Commiss. Oregon, Res. Briefs, **6** (2): 21–4. Portland, 1955.

Roppel, A. Y. "Peak hours of pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon fry migration from Old Tom Creek, S. E. Alaska, 1952." Copeia, 2: 110. Baltimore, 1956.

Royal, L. A. "The international Fraser River sockeye salmon fishery." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 243–55. New York, 1956.

Schoning, R. W., & Johnson, D. R. "A measured delay in the migration of adult chinook salmon at Bonneville Dam on the Columbia River." Contrib. Fish. Commiss. Oregon, **23**. Portland, 1956.

Snieszko, S. F., & Wood, E. M. "The effect of some sulphonamides on the growth of brook trout, brown trout, and rainbow trout." Trans. American Fish. Soc., **84**: 86–92. New York, 1955.

Stringer, G. E., & Hoar, W. S. "Aggressive behaviour of underyearling Kamloops trout." Canadian J. Zool., **33** (3): 148–60. Ottawa, 1955.

Wales, J. H., & German, E. R. "Castle Lake investigation – second phase: Eastern Brook trout." California Fish & Game, **42** (2): 93–108. Sacramento, 1956.

Welander, A. D. "Some effects of X-irradiation of different embryonic stages of the trout (*Salmo gairdnerii*)." Growth, **18** (4): 227–55. Philadelphia, 1954.

Went, A. E. J. "Irish salmon and salmon fisheries being the Buckland Lectures for 1953." Edward Arnold (Pub.) Ltd. London, 1955.

Wood, J. W. "Kidney disease in adult chinook salmon and its transmission by feeding to young chinook salmon." Fish. Commiss. Oregon, Res. Briefs, **6** (2): 32–40. Portland, 1955.

Young, G. E., & Smith, D. G. "The amino acids in the ichthyolkeratin of salmon eggs." J. Biol. Chem., **219**: 61. Baltimore, 1956.

6) m Eels

Jensen, Aa. J. C. "Eels". ICES, Ann. Biol., **11**. Copenhague, 1956.

Siou, G. "Cholinesterase activity of the aneural zone of the myomeres of the eel." C. R. Soc. Biol., **149**: 1422–5. Paris, 1955.

Smith, M. W. "Control of eels in a lake by preventing the entrance of the young." Canadian Fish Cult., **17**: 13–7. Ottawa, 1955.

6) n Other Freshwater Species

Alikunhi, K. H., Chaudhuri, H., & Ramachandran, V. "On the mortality of carp fry in nursery ponds and the role of plankton in their survival and growth." Indian J. Fish., **2** (2): 257–313. Bangalore, 1955.

Baerends, G. P., Brouwer, R., & Waterbolk, H. T. "Ethological studies on *Lebistes reticulatus* (Peters). I. An analysis of the male courtship pattern." Behaviour, **8** (4): 249–334. Leiden, 1955.

Berzins, B. "Värdet av fenklippningsmetoden vid märkning av gäddungar. 3". Skr. Södra Sveriges Fisk., Årsskr. 1954–55: 19–21. Lund, 1956.

El-Zarka, S. "Breeding behaviour of the Egyptian cichlid fish, *Tilapia zilli*." Copeia, 2: 112. Baltimore, 1956.

Gelineo, A., & Gelineo, S. "Concentration of hemoglobin in the blood of some fresh water fishes." C. R. Soc. Biol., **149**: 1410–1. Paris, 1955.

Golovinskaja, K. A., & Musselius, V. A. "Experiment to rear yearling carps." Rybn. Khoz., 4: 41. Moscow, 1956.

Gray, E. G. "Control of the melanophores of the minnow (*Phoxinus phoxinus* (L.))." J. Exper. Biol., **33** (2): 448–59. Cambridge, 1956.

Healy, A. "Pike (*Esox lucius* L.) in three Irish lakes." Sci. Proc. Roy. Dublin Soc., **27** (4). Dublin, 1956.

Järvi, T. H. "Über den Maränenbestand im Pyhäjärvi (SW-Finnland). Zweiter Beitrag: Die Jahre 1940–1945." Acta Zool. Fennica, **74**: 1–47. Helsinki, 1953.

Järvi, T. H. "Über die Coregonen s. str. im Päijänne und in einigen anderen Gewässern Mittelfinnlands." Acta Zool. Fennica, **75**: 1–33. Helsinki, 1953.

Jørgensen, C. B., & Rosenkilde, P. "On regulation of concentration and content of chloride in goldfish." Biol. Bull., **110** (3): 300–5. Lancaster, Pa., 1956.

Kaneev, A. E. "Curing carps infested with *Caryophyllaeus laticeps* and *C. fimbriceps* (Nematodes)." Rybn. Khoz., 4: 50. Moscow, 1956.

Karamchandani, S. J. "Mortality of a carp fry due to infection by a parasitic ciliate." Current Sci., **25** (4): 126–7. Bangalore, 1956.

Larkin, P. A. "Interspecific competition and population control in freshwater fish." J. Fish. Res. Board Canada, **13** (3): 327–42. Ottawa, 1956.

Lowe, R. H. (McConnell). "The breeding behaviour of *Tilapia* species (Pisces; Cichlidae) in natural waters: observations on *T. karomo* Poll and *T. variabilis* Boulenger." Behaviour, **9** (2–3): 140–63. Leiden, 1956.

Lyall, A. H. "Occurrence of triple and quadruple cones in the retina of the minnow (*Phoxinus laevis*)". Nature, **177** (4519): 1086. London, 1956.

Moskalenko, B. K. "Influence of the several years' fluctuations of the water level of the Ob river on the fecundity and reproduction of certain fishes." Zool. Zhurn., **35** (5): 746. Moscow, 1956.

Pick, G. "Reducing the loss of carp fry caused during storage in the Upper Galilaea." Bamidgeh, Bull. Fish. Cult. Israel, **8** (2): 27–31. Hakirya, 1956.

Pittrof, G. "Pathologische Befunde an Leber und Darm von Karpfen (*Cyprinus carpio*) nach natürlicher und künstlicher Infektion mit pathogenen Pseudomonas-bakterien." Univ. München. München, 1955.

Rogers, K. T. "Re-examination of the production of cyclopia in *Fundulus heteroclitus* with magnesium chloride and ethyl alcohol." Biol. Bull., **110** (3): 344–51. Lancaster, Pa., 1956.

Saha, K. C., & Chowdhury, N. K. "Studies on the mortality in spawn and fry of Indian major carps during transport. Part I. Investigations relating to the use of specific soil (red soil) – water medium in transporting carp spawn ('Dimpona') in the existing trade to check mortality during transit." Indian J. Fish., **3** (1): 119–26. Bangalore, 1956.

Saha, K. C., Sen, D. P., & Mazumdar, P. "Studies on the mortality in spawn and fry of Indian major carps during transport. Part II. Effect of oxygen pressure, free surface area, water volume and number of fry in the medium of transport." Indian J. Fish., **3** (1): 127–34. Bangalore, 1956.

Saha, K. C., Sen, D. P., & Mazumdar, P. "Studies on the mortality of spawn and fry of Indian major carps during transport. Part III. The effect of inimical substances from decomposition of metabolic products in the medium on spawn life and their control." Indian J. Fish., **3** (1): 135–40. Bangalore, 1956.

Schultz, F. H. "Field identification of Rocky Mountain and common whitefish." Canadian Fish Cult., **17**: 1–5. Ottawa, 1955.

Srinivasan, R., Chacko, P. I., & Valsan, A. P. "A preliminary note on the utility of sodium phosphate in the transport of fingerlings of Indian carps." Indian J. Fish., **2** (1): 77–83. Bangalore, 1955.

Tateishi, S. "On the lot of unspawned eggs of *Cyprinus auratus* Linné." Bull. Fac. Fish. Nagasaki Univ., **4**: 26–30. Sasebo, 1956.

Woodhead, P. M. J. "The behaviour of minnows (*Phoxinus phoxinus* L.) in a light gradient." J. Exper. Biol., **33** (2): 257–70. Cambridge, 1956.

Yashouv, A. "Report on the growth of *Tilapia gallilaea artedi* at the Fish Culture Research Station – Dor." Bamidgeh, Bull. Fish Cult. Israel, **8** (2): 31–4. Hakirya, 1956.

Yukheva, V. S. "The annual food cycle of the Tasov whitefish (*Coregonus sardinella* Val.)" Zool. Zhurn., **34** (1): 158–61. Moscow, 1955.

6) o General

Amemiya, I. "Study on the amount of internal organs in fish, with some reference to its meaning on their habit." Rev. Fish. Sci. Japan, Japanese Soc. Advancem. Sci.: 200–23. 1954.

Ammann, F. "Der Befall der Bodenseefische mit Triaenophorus unter besonderer Berüchsichtigung des biologischen Cyclus." Univ. München. München, 1955.

Asano, M., Ito, M., & Kumagai, T. "Comparative biochemical studies on aquatic animals. I. Calcium turnover of the freshwater fish and shellfish." Tohoku J. Agric. Res., **6** (4): 341–60. Sendai, 1956.

Bagge, O., Bertelsen, E., Dannevig, A., Jensen, Aa. J. C., Jensen, I. B., Joensen, J. S., Kändler, R., Knudsen, J., Rae, B. B., & Wilson, E. "Various fish." ICES, Ann. Biol., **11**. Copenhague, 1956.

Bangham, R. V. "Studies on fish parasites of Lake Huron and Manitoulin Island." American Midl. Natur., **53** (1): 184–94. Notre Dame, Ind., 1955.

Barrow, J. H. "Social behaviour in freshwater fish and its effect on resistance to trypanosomes." Proc. Nation. Acad. Sci., **41** (9): 676–9. Washington, 1955.

Belloc, G. "The conservation of biological resources in coastal waters." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 122–6. New York, 1956.

Bertelsen, E., & Marshall, N. B. "The Miripinnati, a new order of teleost fishes." Dana-Rep., **42**. Copenhagen, 1956.

Beverton, R. J. H., & Holt, S. J. "A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling." ICES, R. et P.-V., **140** (1): 67–83. Copenhague, 1956.

Beverton, R. J. H., & Parrish, B. B. "Commercial statistics in fish population studies." ICES, R. et P.-V., **140** (1): 58–66. Copenhague, 1956.

Bigelow, H. B. "Deep water elasmobranchs and chimaeroids from the northwestern Atlantic slope." Bull. Mus. Comp. Zool. Harvard Univ., **112** (2): 35–87. Cambridge, Mass., 1954.

Bigelow, H. B., & Schroeder, W. C. "Occurrence off the Middle and North Atlantic United States of the offshore hake *Merluccius albidus* (Mitchill) 1818, and of the blue whiting *Gadus* (*Micromesistius*) *poutassou* (Risso) 1826." Bull. Mus. Comp. Zool. Harvard Univ., **113** (2): 203–26. Cambridge, Mass., 1955.

Blackburn, M. "Real and apparent changes in size of marine animal populations during the Australian fisheries investigations." ICES, J. du Cons., **21** (3): 284–95. Copenhague, 1956.

Boschung, H. T., & Mallory, J. C. "A record of the lancelet, *Branchiostoma caribaem*, from the stomach of a sturgeon from the Gulf coast of Alabama." Copeia, 2: 116. Baltimore, 1956.

Bouxin, H., & Legendre, R. "Présence de deux espèces de cirripèdes thoraciques sur les rayons branchiostèges d'un squale pélérin." Bull. Soc. Zool. France, **77** (2/3): 119–24. Paris, 1952.

Branter, G. "Die Unabhängigkeit des morphologischen Farbwechsels vom physiologischen Farbwechsel bei der Entstehung des Hochzeitskleides des männlichen Bitterlings." Zeitschr. Vergl. Physiol., **38** (4): 324–33. Berlin, 1956.

Breder, C. M., & Rasquin, P. "Further notes on the pigmentary behaviour of *Chaetodipterus* in reference to background and water transparency." Zoologica, **40** (7): 85–90. New York, 1955.

Burd, A. C., & Gulland, J. A. "The English fish sampling programme." ICES, R. et P.-V., **140** (1): 102–6. Copenhague, 1956.

Burgess, G. H. O. "Absence of keratin in teleost epidermis." Nature, **178** (4524): 93–4. London, 1956.

Castrejon, B. B., & Flores, I. S. "Estudio de los factores que determinan las alteraciónes cromaticas en *Carassius aurata* (carpa). 1. Technica de hipofisectomia." Rev. Soc. Mexicana Hist. Natur., **14** (1/4): 59–61. Mexico, 1953.

Coates, C. W. "Three more gymnotid eels found to be electrogenic." Zoologica, **40** (4): 197–8. New York, 1955.

Coker, R. E. "Role of science in marine fisheries: limitations and potentialities." Scientific Monthly, **82** (4): 176–93. New York, 1956.

Das, S. M., & Saxena, D. B. "Circulation of the blood in the respiratory region of the fishes *Labeo rohita* and *Ophicephalus striatus*." Copeia, 2: 100–8. Baltimore, 1956.

Dempster, R. P. "The use of copper sulphate as a cure for fish diseases caused by parasitic dinoflagellates of the genus *Oodinium*." Zoologica, **40** (3): 133–8. New York, 1955.

Dollfus, R. P. "Première contribution à l'établissement d'un fichier ichthyologique du Maroc Atlantique de Tanger à l'embouchure de l'oued Dra." Trav. Inst. Sci. Chérif., Sér. Zool., **6**. Tanger, 1955.

Drilhon, A. "Euglobulins of fish." C. R. Soc. Biol., **149**: 2124–6. Paris, 1955.

Duncan, R. E. "Use of infrared radiation in the study of fish behaviour." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., **170**. Washington, 1956.

Dunstan, W. A., & Bostick, W. E. "New tatooing devices for marking juvenile salmon." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 70–9. Washington, 1956.

Elpiner, I. E., *et al.* "Effect of ultrasonic waves on ectoparasites of fishes." Rybn. Khoz., 3: 70. Moscow, 1956.

Fänge, R., & Östlund, E. "The effects of adrenaline, noradrenaline, tyramine and other drugs on the isolated heart from marine vertebrates and a cephalopod (*Eledone cirrosa*)." Acta Zool., **35** (3): 290–305. Stockholm, 1954.

Felix, K., Jilke, I., & Zahn, R. K. "Deoxyribonucleic acid of some fish sperms." Hoppe-Seyler's Zeitschr. Physiol. Chem., **303**: 140–52. Strassburg, 1956.

Figuéras, A. "Consideraciónes sobre la preparación y utilidad de los otolitos en el estudio de la edad y crecimiento de los peces." Invest. Pesqu., **4**: 25–45. Barcelona, 1956.

Ghadially, F. N. "Culturing eggs of the brine shrimp." Aquarist, **21** (2): 31–3. London, 1956.

Ghanekar, D. S., & Bal, D. V. "The enzymes of some elasmobranchs from Bombay. I. Proteases." Indian J. Fish., **2** (2): 349–59. Bangalore, 1956.

Gomes, A. L. "Possibilidades da pesca maritima no Brasil." Rev. Biol. Mar., **6**: 5–20. Valparaiso, 1955.

Gosline, W. A. "The osteology and relationships of certain gobioid fishes, with particular reference to the genera *Kraemeria* and *Microdesmus*." Pacific Sci., **9**: 158–70. Honolulu, 1955.

Graham, M. "Concepts of conservation." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 1–13. New York, 1956.

Graham, M. "A first approximation to a modern theory of fishing." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 56–60. New York, 1956.

Gulland, J. A. "The study of fish populations by the analysis of commercial catches. A statistical review." ICES, R. et P.-V., **140** (1): 28-9. Copenhague, 1956.

Halstead, B. W., & Schall, D. W. "A report on the poisonous fishes captured during the Woodrow G. Krieger Expedition to the Galapagos Islands." Essays Natur. Sci. Allan Hancock: 147–72. Los Angeles, 1955.

Hansen, P. "The importance of conservation of stocks of fish and sea mammals in arctic waters." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 322–5. New York, 1956.

Hardisty, M. W. "Some aspects of osmotic regulation in lampreys." J. Exper. Biol., **33** (2): 431–47. Cambridge, 1956.

Hargis, W. J. "A new species of *Benedenis* (Trematoda: Monogenea) from *Girella nigricans*, the opaleye." J. Parasitol., **41** (1): 48–50. Lancaster, Pa., 1955.

Hargis, W. J. "Monogenetic trematodes of Gulf of Mexico fishes. II. The superfamily Gyrodactyloidea. (Continued)." J. Parasitol., **41** (2): 185–93. Lancaster, Pa., 1955.

Hargis, W. J. "Monogenetic trematodes of Gulf of Mexico fishes. V. The superfamily Capsaloidea." Trans. American Microscop. Soc., **74** (3): 203–25. Columbus, Ohio, 1955.

Hargis, W. J. "Monogenetic trematodes of Gulf of Mexico fishes. VI. The superfamilies Polystomatoidea Price 1936 and Diclidophoroidea Price 1936." Trans. American Microscop. Soc., **74** (4): 361–77. Columbus, Ohio, 1955.

Hargis, W. J. "Monogenetic trematodes of Gulf of Mexico fishes. IX. The family Diclidophoridae Fuhrmann 1928." Trans. American Microscop. Soc., **74** (4): 377–88. Columbus, Ohio, 1955.

Harris, J. E. "The development of swimming movements in the embryo of the dogfish, *Scyliorhinus canicula*." Ann. Acad. Sci. Fennicae, Ser. A, IV, Biol., **29**: 1–11. Helsinki, 1955.

Hasler, A. D. "Influence of environmental reference points on learned orientation in fish (*Phoxinus*)." Zeitschr. Vergl. Physiol., **38** (4): 303–10. Berlin, 1956.

Herre, A. W. "Marine fishes in fresh water." Science, **123** (3206): 1035. Lancaster, Pa., 1956.

Herrington, W. C., & Kask, J. L. "International conservation problems, and solutions in existing conventions." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 145–66. New York, 1956.

Hirohata, R., Ikoma, T., Ohta, S., Fuji, S., & Morizawa, S. "Polypeptides isolated from mugiline." Congr. Internat. Biochim., Résumés comm., 3rd Congr. Brussels 1955: 15. Brussels, 1956.

Holder, J., Heinemann, H. O., Fishman, A. P., & Smith, H. W. "Urine pH and carbonic anhydrase activity in the marine dogfish." American J. Physiol., **183** (1): 155–62. Boston, 1955.

Ignatieva, G. M. "The part played by membranes in the secretion of the hatching-enzyme in Acipenseridae embryos." Dokl. Akad. Nauk SSSR, **107** (3): 493. Moscow, 1956.

Irie, T. "The crystal texture of the otolith of a marine teleost *Pseudosciaena*." J. Fac. Fish. & Anim. Husbandry, Hiroshima Univ., **1** (1): 1–8. Fukuyama, 1955.

Jones, R. "The analysis of trawl haul statistics with particular reference to the estimation of survival rates." ICES, R. et P.-V., **140** (1): 30–9. Copenhague, 1956.

Jones, R. "A discussion of some limitations of the trawl as a sampling instrument." ICES, R. et P.-V., **140** (1): 44–7. Copenhague, 1956.

Kawabata, T. "Radiologic contamination of fish. I. Distribution and migration of contaminated fish on basis of the compiled data of radiological surveys." Japanese J. Med. Sci. Biol., **8**: 337–46. Tokyo, 1955.

Kawabata, T. "Radiologic contamination of fish. 2. Actual state of radiologic contamination in fish and its possible routes on the basis of the findings of the 'Bikini Expedition'". Japanese J. Med. Sci. Biol., **8**: 347–58. Tokyo, 1955.

Kawabata, T. "Radiologic contamination of fish. 3. Radiochemical studies of contaminated fish." Japanese J. Med. Sci. Biol., **8**: 359–72. Tokyo, 1955.

Keenleyside, M. H. A. "Some aspects of the schooling behaviour of fish." Behaviour, **8** (2–3): 183–248. Leiden, 1955.

Ketchen, K. S. "Climatic trends and fluctuations in yield of marine fisheries of the Northeast Pacific." J. Fish. Res. Board Canada, **13** (3): 357–74. Ottawa, 1956.

Kinne, O. "Über Temperatur und Salzgehalt und ihre physiologisch-biologische Bedeutung." Biol. Zentralbl., **75** (3/6): 314–27. Leipzig, 1956.

Kinoshita, H. "Studies on the mechanism of pigment migration within fish melanophores with special reference to their electric potentials." Annot. Zool. Japonenses, **26** (2): 115–27. Tokyo, 1953.

Kirikcic, J., & Lepetic, V. "Recherches sur l'ichtyobenthos dans les profondeurs de l'Adriatique méridionale et possibilité d'exploitation au moyen des palangres." Acta Adriatica, **7** (1). Split, 1955.

Kobayashi, S., Yuki, R., & Hirata, H. "A preliminary test for recording the feeding activity in fish." Bull. Fac. Fish. Hokkaido Univ., **6** (4): 235–8. Hakodate, 1956.

Kobayashi, S., Yuki, R., & Hirata, H. "Fishes from the northern Pacific and from Bristol Bay." Bull. Fac. Fish. Hokkaido Univ., **6** (4): 239–65. Hakodate, 1956.

Krumholz, L. A. "Observations on the fish population of a lake contaminated by radioactive wastes." Bull. American Mus. Natur. Hist., **110** (4): 277–368. New York, 1956.

Kuiper, J. W. "Measurements on the microphonic activity of the lateral line organ." Acta Physiol. Pharmacol., Neerlandica, **4** (3): 426–7. Amsterdam, 1955.

Laroze, A. "Toxic action of iron on fish." Ann. Fac. Farm. Porto, **15**: 33–43. Porto, 1955.

Laroze, A. "Effect of poisons on fish." Ann. Fac. Farm. Porto, **15**: 77–111. Porto, 1955.

Lavagna, M. F. "Biochemistry of fish lenses; comparative study of the water content of animal lenses." Bull. Soc. Française d'Ophtalmol. 1954: 67. Paris, 1955.

Leloup, E. "Contribution à l'étude de la faune belge. XXII. Observations sur des poissons marins en 1952." Bull. Inst. Roy. Sci. Natur. Belgique, **29** (48): 1–5. Bruxelles, 1952.

Lindenberg, A., & Gary-Bobo, C. "Alcoholic narcosis in fish." Arch. Sci. Physiol., **6** (1): 3–24. Paris, 1952.

Lindsey, C. C. "Evolution of meristic relations in the dorsal and anal fins of teleost fishes." Trans. Roy. Soc. Canada, Ser. 3, **49** (5): 35–49. Ottawa, 1955.

Lowenstein, O. "The effect of galvanic polarization on the impulse discharge from sense endings in the isolated labrynth of the thornback ray (*Raja clavata*)." J. Physiol., **127** (1): 104–17. London, 1955.

Lozano Cabo, F. "Una campaña de prospección pesquera en Mar Menor (Murcia)." Bol. Inst. Español Oceanogr., **66**: 1–33. Madrid, 1954.

Lozinov, A. B. "Reaction of young sturgeons to oxygen deficiency in relation to temperature." Zool. Zhurn., **31**: 686–95. Moscow, 1952.

Lucas, C. E. "Regulation of North Sea fisheries under the convention of 1946." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 167–82. New York, 1956.

Lucio, A. R. "Datos sobre la edad del bacalao (*G. callarias* L.), eglefino (*Melanogrammus aeglefinus* L.), colin (*Pollachius virens* L.) y locha (*Urophycis tenuis* Mitch.) con indicación de las tecnicas usadas." Bol. Inst. Español Oceanogr., **73**. Madrid, 1955.

Lundbeck, J. "Information on sampling and working methods in market investigations of the German deep-sea fisheries." ICES, R. et P.-V., **140** (1): 94–100. Copenhague, 1956.

Manter, H. W. "Two new monogenetic trematodes from elephant fishes (*Callorhynchus*) from South Africa and New Zealand." Essays Natur. Sci. Allan Hancock: 211–20. Los Angeles, 1955.

Manter, H. W. "The zoogeography of trematodes of marine fishes." Exp. Parasitol., **4** (1): 62–86. New York, 1955.

Margalef, R. "Información y diversidad especifica en las comunidades de organismos." Invest. Pesqu., **3**: 99–106. Barcelona, 1956.

Margetts, A. R. "The sampling of demersal fish stocks by trawls and seines." ICES, R. et P.-V., **140** (1): 40–3. Copenhague, 1956.

Marr, J. C. "The 'critical period' in the early life history of marine fishes." ICES, J. du Cons., **21** (2): 160–70. Copenhague, 1956.

McKinley, W. R., & Webb, R. D. "A proposed correction of migratory fish problems at box culverts." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 33–45. Washington, 1956.

Miller, R. "Plastic bags for carrying and shipping live fish." Copeia, 2: 118–9. Baltimore, 1956.

Moiseev, P. "Fluctuations in the commercial fish populations of the north-western Pacific in relation to environmental and other factors." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 266–89. New York, 1956.

Morawa, F. "Der Nährwert unserer Fische." Allg. Fisch.-Zeit., 9. München, 1955.

Morris, R. W. "Early larvae of four species of rockfish, *Sebastodes*." California Fish & Game, **42** (2): 149–53. Sacramento, 1956.

O'Connell, C. P. "The gas bladders and its relation to the inner ear in *Sardinops caerulea* and *Engraulis mordax*." US Dept. Inter., Fish & Wildl. Serv., Fish. Bull., **56** (104). Washington, 1955.

Panek, K. "Contribution to the method of determination of the age of fishes, especially according to the otoliths." Sbornik Vysoke Skoly Zemed. Brno B. B.: Spisy Fak. Vet., **2** (1/2): 9–17. 1954.

Parrish, B. B. "Outline of sampling methods used in Scottish fish population studies." ICES, R. et P.-V., **140** (1): 107–8. Copenhague, 1956.

Parrish, B. B., & Beverton, R. J. H. "Review of symposium. Problems and methods of sampling fish populations." ICES, R. et P.-V., **140** (1): 7–10. Copenhague, 1956.

Perlmutter, A. "Age determination of fish." Trans. New York Acad. Sci., **16** (6): 305–11. New York, 1954.

Poulsen, E. M. "Conservation problems in the north-western Atlantic." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 183–93. New York, 1956.

Prabhu, M. S. "Maturation of intra-ovarian eggs and spawning periodicities in some fishes." Indian J. Fish., **3** (1): 59–90. Bangalore, 1956.

Pradhan, L. B., & Kapadia, P. N. "The relation between the length of fish and the weight and density of otolith and bone, and the rate of ossification." J. Univ. Bombay, **22** (3): 32–40. Bombay, 1953.

Prudhoe, S. "On a new trematode from South African fishes." Ann. Mag. Natur. Hist., Ser. 12, **9** (97): 72–5. London, 1956.

Qasim, S. Z. "Time and duration of the spawning season in some marine teleosts in relation to their distribution." ICES, J. du Cons., **21** (2): 144–55. Copenhague, 1956.

Rae, B. B., & Wilson, E. "Rare and exotic fishes recorded in Scotland during 1952." Scottish Natur., **65** (3): 141–53. Edinburgh, 1953.

Ramaswami, L. S. "Skeleton of cyprinoid fishes in relation to phylogenetic studies. 6. The skull and weberian apparatus in the subfamily Gobioninae (Cyprinidae)." Acta Zool., **36** (2): 127–58. Stockholm, 1955.

Ramaswami, L. S. "Induced spawning in the Indian catfish." Science, **123** (3205): 1080. Lancaster, Pa., 1956.

Randall, J. E. "An analysis of the genera of surgeon fishes (family Acanthuridae)." Pacific Sci., **9** (3): 359–67. Honolulu, 1955.

Randall, J. E. "A revision of the surgeon fish genus *Acanthurus*." Pacific Sci., **10** (2): 159–235. Honolulu, 1956.

Randall, J. E. "A revision of a surgeon fish genus *Ctenochaetus*, family Acanthuridae, with descriptions of 5 new species." Zoologica, **40** (4): 149–66. New York, 1955.

Ribeiro de Moraes, J. "Consideracoes sobre a pesca maritima no Estado de São Paulo." Rev. Biol. Mar., **6**: 155–69. Valparaiso, 1955.

Ridgway, G. J. "Some cytological observations on fish erythrocytes." Progr. Fish-Cult., **18** (2): 67–9. Washington, 1956.

Rigdon, R. H., & Hendricks, J. W. "Myxosporidia in fish in waters emptying into Gulf of Mexico." J. Parasitol., **41** (5): 511–8. Lancaster, Pa., 1955.

Riser, N. W. "Studies on cestode parasites of sharks and skates." J. Tennessee Acad. Sci., **30** (4): 265–312. Nashville, 1955.

Rogozina, I. V. "Investigation of mature eggcells in *Petromyzon fluviatilis* with the aid of luminescence, ultra-violet and anoptral microscopy and by certain histochemical methods." Dokl. Akad. Nauk SSSR, **107** (4): 592. Moscow, 1956.

Rossi-Fanelli, A., & Antonini, E. "Purification and crystallization of the myoglobin of salt water fish." Arch. Biochem. Biophys., **58** (2): 498–500. New York, 1955.

Saito, T., & Arai, K. "Studies on the inorganic phosphates in muscle of the aquatic animals. I. On the determination of adenosine-polyphosphates in muscle of carp." Bull. Fac. Fish. Hokkaido Univ., **6** (3): 228–33. Hakodate, 1955.

Saunders, D. C. "The occurrence of *Haemogregarina higemina* Laveran and Mesnil and *H. achiri* n. sp. in marine fish from Florida." J. Parasitol., **41**: 171–8. Lancaster, Pa., 1955.

Schaefer, M. B. "The scientific basis for a conservation programme." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 14–55. New York, 1956.

Sette, O. E. "Consideration of midocean fish production as related to oceanic circulatory systems." J. Mar. Res., **14** (4): 398–414. New Haven, Conn., 1955.

Shalumovich, V. N. "Investigation of the membrane of a mature eggcell in *Petromyzon fluviatilis* with the aid of luminescence ultra-violet and anoptral microscopy." Dokl. Akad. Nauk SSSR, **107** (4): 594. Moscow, 1956.

Smith, J. L. B. "An extraordinary fish from South Africa." Ann. Mag. Natur. Hist., Ser. 12, **9** (97): 54–7. London, 1956.

Starrett, A., & Starrett, P. "Observations on young blackfish, *Globicephala*." J. Mammal., **36** (3): 424–9. Baltimore, 1955.

Steinitz, H., & Ben-Tuvia, A. "Fishes from Eylath (Gulf of Aqaba), Red Sea. Second Report." State Israel Sea Fish Res. Stat., Bull., **11**. Haifa, 1955.

Strawn, K., & Hubbs, C. "Observations on stripping small fishes for experimental purposes." Copeia, 2: 114–6. Baltimore, 1956.

Stryjecka-Trembaczowska, M. "Investigations on Urceolariidae (Ciliata-Peritricha) of the gills of fishes of the Polish Baltic Sea." Acta Parasitol. Polonica, **1** (1/8): 85–119. Warsaw, 1953.

Suyehiro, Y., *et al.* "Notes on the action of radioactive substances on aquatic animals." Science (Japan), **24**: 619–22. 1954.

Szidat, L. "Über die Parasitenfauna von *Percichthys trucha* (Cuv. & Val.) Girard der patagonischen Gewässer und die Beziehungen des Wirtfisches und seiner Parasiten zur paläarktischen Region." Arch. Hydrobiol., **51** (4): 542–77. Stuttgart, 1956.

Tait, J. B. "Role of the environment in the biology of economically valuable stocks". Pap. Internat. Tech. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 62. New York, 1956.

Tait, J. B. "Outstanding questions: fluctuations in food fish stocks; nutrition of fish; tropisms of fish." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 81–4. New York, 1956.

Tait, J. S. "Nitrogen and argon in salmonoid swimbladders." Canadian J. Zool., **34**: 58–62. Ottawa, 1956.

THOMOPOULOS, A. "Sur l'oeuf d'équille (*Ammodytes tobianus* L.)." Bull. Soc. Zool. France, **79** (2/3): 112–20. Paris, 1954.

THREINEN, C. W. "The success of a seine in the sampling of a largemouth bass population." Progr. Fish-Cult., **18** (2): 81–7. Washington, 1956.

TIMOFEEVA, N. A. "Use of netted cultures for rearing young sturgeons." Rybn. Khoz., 4: 48. Moscow, 1956.

TIMOFEUK, M. V., & ZHUKOVSKII, G. M. "Floating tables for feeding fishes in ponds." Rybn. Khoz., 4: 47. Moscow, 1956.

TITOVA, L. K. "The development of the olfactory organ in fishes and amphibians." Dokl. Akad. Nauk SSSR, **107** (5): 749. Moscow, 1956.

TSUCHIYA, Y., & NOMURA, T. "Blue-green pigments of the integuments of fishes. I. Isolation of ichthyoverdin from the scales of *Colabis saira*." Tohoku J. Agric. Res., **6**: 75–83. Sendai, 1955.

VON UBISCH, L. "Kurze Mitteilung über Inversion bei Bastarden von *Pleuronectes platessa* ♀ und *P. flesus* ♂ mit normal rechtsgewandten und inversen Vatern." Wilhelm Roux' Arch. Entwicklungsmech. Organ., **146** (4): 589–92. Leipzig, 1953.

WEITZEL, G., *et al.* "Zink und Insulin im Pankreas von Knochenfischen." Hoppe-Seyler's Zeitschr. Physiol. Chem., **295**: 83–106. Berlin, 1953.

WIDE, E. "Elfiske 4. Redogörelse över några sötvattensfiskars reaktioner i elfältet vid elfiske." Södra Sveriges Fiskeriförening. 1906–1955: 113–8. Lund, 1956.

WOLFGANG, R. W. "Studies of the trematode *Stephanostomum baccatum* (NICOLL 1907). III. Its life cycle." Canadian J. Zool., **33** (3): 113–28. Ottawa, 1955.

YANEZ, P. "Peces utiles de la costa chilena." Rev. Biol. Mar., **6**: 29–81. Valparaiso, 1955.

YOUNG, R. T. "Two new spp. of *Echeneibothrium* from the stingray *Urobatis halleri*." Trans. American Microscop. Soc., **74** (3): 232–4. Columbus, Ohio, 1955.

ZAITSEV, IU. P. "A method of collecting pelagic fish eggs in parts of the sea subject to rapid evaporation." Zool. Zhurn., **34** (2): 380–2. Moscow, 1955.

ZUPANOVIC, S. "Productivity and intensity of exploitation of the Adriatic." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 326–37. New York, 1956.

7) Shellfish

7) a Molluscs

ANON. "The Zeeland mussel-culture." Holland Fish Trade, **14**: 1, 3, & 5. The Hague, 1956.

ANON. "Le captage du naissain d'huîtres portugaises en vilaine." Sci. et Pêche, **34**: 1–7. Paris, 1956.

ASANO, M., ITO, M., & KUMAGAI, T. "Comparative biochemical studies on aquatic animals. I. Calcium turnover of the freshwater fish and shellfish." Tohoku J. Agric. Res., **6** (4): 341–60. Sendai, 1956.

BEAVEN, G. F. "Some observations on the rate of growth of oysters in the Maryland area." Proc. Nation. Shellf. Assoc. 1952: 79–89. Washington, 1953.

BROWN, F. A., *et al.* "Persistent daily, monthly, and 27-day cycles of activity in the oyster and quahog." J. Exper. Zool., **131** (2): 235–62. Philadelphia, 1956.

BUTLER, P. A. "Shell growth versus meat yield in the oyster, *C. virginica*." Proc. Nation. Shellf. Assoc. 1952: 157–62. Washington, 1953.

CHESTNUT, A. F., & FAHY, W. E. "Studies on the setting intensity of oysters in Bogue Sound, North Carolina." Proc. Nation. Shellf. Assoc. 1952: 90–8. Washington, 1953.

DAVIS, H. C. "On food and feeding of larvae of the american oyster, *C. virginica*." Proc. Nation. Shellf. Assoc. 1952: 54–69. Washington, 1953.

DAVIS, H. C., & CHANLEY, P. E. "Spawning and egg production of oysters and clams." Biol. Bull., **110** (2): 117–28. Lancaster, Pa., 1956.

DAWSON, C. E. "Observations on the incidence of *Dermocystidium marinum* infection in oysters of Apalachicola Bay, Florida." Texas J. Sci., **7** (1): 47–56. San Marcos, 1955.

FINGERMAN, M., & FAIRBANKS, L. D. "Some factors affecting fluid loss in southern oysters." Commerc. Fish. Rev., **18** (10): 11. Washington, 1956.

Flower, F. B., & McDermott, J. J. "Observations on the occurrence of oyster crab *Pinnotheres ostreum* as related to oyster damage in Delaware Bay." Proc. Nation. Shellf. Assoc. 1952: 44–6. Washington, 1953.

Fraga, F. "Determinación de glucogeno en moluscos con el reactivo de antrona." Invest. Pesqu., **3**: 69–74. Barcelona, 1956.

Fraga, F. "Variación estacional de la composición quimica del mejillon (*Mytilus edulis*). I." Invest. Pesqu., **4**: 109–25. Barcelona, 1956.

Glude, J., Spear, H., & Wallace, D. "The hydraulic clam rake, a new method of gathering seed clams." Proc. Nation. Shellf. Assoc. 1952: 163–6. Washington, 1953.

Imai, T., Sakai, S., & Okada, H. "Breeding of the Olympic oyster in tanks and culture experiments in Japanese waters." Tohoku J. Agric. Res., **5** (1): 13–25. Sendai, 1954.

Jeffrey, S. W. "The metabolism of oyster spermatozoa. 5. The effect of glycine." Australian J. Exp. Biol. Med. Sci., **32** (6): 802–12. Adelaide, 1954.

Jeffrey, S. W. "The metabolism of oyster spermatozoa. 6. The effect of metals." Australian J. Exp. Biol. Med. Sci., **32** (6): 813–8. Adelaide, 1954.

Korringa, P., Meyer-Waarden, P. F., & Waugh, G. D. "Oysters and mussels." ICES, Ann. Biol., **11**: 176–86. Copenhague, 1956.

Lackey, J. B., Borgh, G. V., & Glancy, J. B. "General character of plankton organisms in water overlying shellfish-producing grounds." Proc. Nation. Shellf. Assoc. 1952: 152–6. Washington, 1953.

Lacy, D., & Rogers, G. E. "Recent observations by light and electron microscopy on the cytoplasmic inclusions of the neurones of *Patella vulgata*." J. Roy. Microscop. Soc., Ser. 3, **75** (3): 172–5. London, 1956.

Ladouce, R., & le Goff, J. "Note sur le reparcage des huîtres importées du Portugal en 1955." Sci. et Pêche, **35**: 3. Paris, 1956.

Loosanoff, V. L. "Behaviour of oysters in water of low salinities." Proc. Nation. Shellf. Assoc. 1952: 135–51. Washington, 1953.

Loosanoff, V. L. "Two obscure oyster enemies in New England waters." Science, **123** (3208): 119–20. Lancaster, Pa., 1956.

Lopez-Benito, M. "Composición quimica de algunos moluscos y crustaceos de la ria de Vigo." Invest. Pesqu. **4**: 127–32. Barcelona, 1956.

Lozano Cabo, F. "Notas anatómicas sobre especies españolas de moluscos de interés pesquero." Bol. Real Soc. Española Hist. Natur., Sec. Biol., **50** (2): 255–78. Madrid, 1952.

Nayar, K. N. "Studies on the growth of the wedge clam, *Donax* (*Latona*) *cuneatus* Linnaeus." Indian J. Fish., **2** (2): 325–48. Bangalore, 1955.

Savage, R. E. "The great spatfall of mussels (*Mytilus edulis* L.) in the River Conway estuary in spring 1940." MAFF, Fish. Invest., Ser. 2, **20** (7). H.M.S.O., London, 1956.

Ranson, G. "Observations on the habits of the pearl oyster (*Pinctada margaritifera*) in relation to its environment." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 112–5. New York, 1956.

Roche, J., Glahn, P. E., & Manchon, P. "Possible transformations of a metabolite of histidine in the presence of homogenates of the hepatopancreas of *Mytilus edulis*." C. R. Soc. Biol., **149**: 2077–9. Paris, 1955.

Sanchez y Sanchez, M. "Cultivo del mejillon en las Rias Gallegas." Industr. Pesqu., **30** (697–698): 45. Vigo, 1956.

Sprague, V., & Orr, P. E. "*Nematopsis ostrearum* and *N. prytherchi* (Eugregarinina: Porosporidae) with special reference to the host-parasite relations." J. Parasitol., **41** (1): 89–104. Lancaster, Pa., 1955.

Venkataraman, R., & Sreenivasan, A. "Mussel pollution at Korapuzha estuary (Malabar), with an account of certain coliform types." Indian J. Fish., **2** (2): 314–24. Bangalore, 1955.

Walne, P. R. "Bacteria in experiments on rearing oyster larvae." Nature, **178** (4524): 91. London, 1956.

Westley, R. E. "Retention of Pacific oyster larvae in an inlet with stratified waters." Washington Dept. Fish., Fish. Res. Pap., **1** (4): 25–31. Washington, 1956.

Yasaka, S., Miyahara, S., & Tabata, Y. "Studies on *Pteria martensii* Dunker. II. Determination of heavy metals and amino acids in pearl-layer." Bull. Fac. Fish. Nagasaki Univ., **4**: 45–8. Sasebo, 1956.

7) b Crustaceans

Anderson, W. W. "January to April distribution of the common shrimp on the South Atlantic continental shelf." US Dept. Inter., Fish & Wildl. Serv., Spec. Sci. Rep.-Fish., **171**. Washington, 1956.

Anon. "De Kustvisscher. De Duitse Garnalenvisserij in seizoen 1955–1956." De Visserijwereld, **15** (22): 17–8. 's-Gravenhage, 1956.

Dannevig, A. "Lobsters." ICES, Ann. Biol., **11**: 175. Copenhague, 1956.

Duchâteau, G., & Florkin, M. "Sur la composition de l'arthropodine et de la scléroprotéine cuticulaires de deux crustacés décapodes (*Homarus vulgaris* Edwards et *Callinectes sapidus* Rathbun)." Physiol. Comp. Oecol., **3** (4): 365–9. Amsterdam, 1954.

Gamulin, T. "Contribution à la connaissance de l'écologie de la langouste (*Palinurus vulgaris* Latr.) dans l'Adriatique." Acta Adriatica, **7** (9). Split, 1955.

Higman, J. B. "The behaviour of pink grooved shrimp, *Penaeus duorarum* Burkenroad, in a direct current electrical field." Univ. Miami Mar. Lab., Techn. Ser., **16**. Coral Gables, 1956.

Joubert, F. J. "Haemocyanin of the crawfish (*Jasus lalandii*)." Biochim. Biophys. Acta, **14** (1): 127–35. Amsterdam, 1954.

Lunz, G. R. "The minimum shrimp size regulation in South Carolina." Contrib. Bears Bluff Lab., **16**. Wadmalaw Island, 1954.

Meredith, S. S. "The appendages of *Crangon vulgaris*, the brown shrimp." Proc. Leeds Phil. Lit. Soc., Sci. Sect., **6** (4): 228–42. Leeds, 1954.

Williams, A. B. "A contribution to the life histories of commercial shrimps (Penaeidae) in North Carolina." Bull. Mar. Sci. Gulf & Caribbean, **5** (2): 116–46. Coral Gables, 1955.

Williams, A. B. "A survey of North Carolina shrimp nursery grounds." J. Elisha Mitchell Sci. Soc., **71** (2): 200–7. Chapel Hill, N. C., 1955.

Yasuda, J. "The biological study on the resources of crustaceans in the Inland Sea. (2). A special treatise. The study on the organism of various kinds." Bull. Naikai Reg. Fish. Res. Lab., **9**. Hiroshima, 1955.

8) Mammals and Reptiles

Anon. "International whaling statistics. XXXV." Norske Hvalråds Statist. Publ. Oslo, 1956.

Anon. "International whaling statistics. XXXVI." Norske Hvalråds Statist. Publ. Oslo, 1956.

Breathnach, A. S. "The surface features of the brain of the humpback whale (*Megaptera novaeangliae*)." J. Anat., **89** (3): 343–54. London, 1955.

Figueiredo, J. M. "La pesca Portuguesa del cachalote." Industr. Pesqu., **30** (697–698): 24–7. Vigo, 1956.

Fraser, F. C., & Purvis, P. E. "Fractured ear-bones of blue whales." Scottish Natur., **65** (3): 154–6. Edinburgh, 1953.

Friant, M. "Le cerveau du Baleinoptère (Balaenoptera sp.)" Acta Anat., **23** (3): 242–50. Basel, 1955.

Gregory, M. E., Kon, S. K., Rowland, S. J., & Thompson, S. Y. "The composition of the milk of the blue whale." J. Dairy Res., **22** (1): 108–12. London, 1955.

Hansen, P. "The importance of conservation of stocks of fish and sea mammals in arctic waters." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 322–5. New York, 1956.

Kellogg, R. "The International Whaling Commission." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 256–61. New York, 1956.

KENYON, K. W. "Food of fur seals taken on St. Paul Island, Alaska, 1954." J. Wildl. Managem., **20** (2): 214–5. Ithaca, 1956.

DE KOCK, L. L. "The carotid body of the pilot whale, *Globicephala melaena*." Nature, **177** (4519): 1084. London, 1956.

LAWRENCE, B., & SCHEVILL, W. E. "The functional anatomy of the delphinid nose." Bull. Mus. Comp. Zool. Harvard Univ., **114** (4): Cambridge, Mass., 1956.

LAWS, R. M. "Growth and sexual maturity in aquatic animals." Nature, **178** (4526): 193–4. London, 1956.

LAWS, R. M. "Determination of age of the larger whales (*Mysticeti*)". Polar Rec., **8** (53): 175–6. Cambridge, 1956.

MANSO, J. M. M. "Las tortugas del Orinoco." Industr. Pesqu., **30** (697–98): 40–4. Vigo, 1956.

MATTHEWS, L. H. "Marine mammals of west Wales." Nature in Wales, **1** (2): 49–53. 1955.

MOORE, J. C., & PALMER, R. S. "More piked whales from southern North Atlantic." J. Mammal., **36** (3): 429–33. Baltimore, 1955.

OTTESTAD, P. "On the size of the stock of Antarctic fin whales relative to the size of the catch." Norwegian Whaling Gaz., 1956, 6: 298–308. Sandefjord, 1956.

RUUD, J. T. "International regulation of whaling. A critical survey." Norwegian Whaling Gaz., 1956, 7: 374–87. Sandefjord, 1956.

SCHUBERT, K. "Der Walfang der Gegenwart." Handb. Seefisch. Nordeuropas, **11** (6). Stuttgart, 1955.

UDA, M., & NASU, K. "Studies of the whaling grounds in the northern sea-region of the Pacific Ocean in relation to the meteorological and oceanographical conditions. Part 1." Sci. Rep. Whales Res. Inst., **11**: 163–79. Tokyo, 1956.

9) Miscellaneous

9) a Mathematical and Statistical Methods

OSTLE, B. "Statistics in research. Basic concepts and techniques for research workers." Iowa State College Press. Ames, 1954.

TAMURA, O. "Studies on the Japanese sardine. (V). Study on the x^2 method of vertebral compositions. (2)." Bull. Fac. Fish. Nagasaki Univ., **4**: 77–85. Sasebo, 1956.

9) b General

GOEDECKE, E. "Zur Frage der rezenten Klimaschwankung über den Britischen Inseln und zum Problem der säkularen Erwärmung auf der Nordhalbkugel." Ann. Meteorol., **7** (5/6): 225–49. Hamburg, 1956.

HERRINGTON, W. C. "Comments on the principle of abstention." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 344–9. New York, 1956.

KESTEVEN, G. L., & HOLT, S. J. "Classification of international conservation problems." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 350–71. New York, 1956.

RICHTER, J. "Geschwindigkeitsäquivalente der Windstärkeschätzungen nach Beobachtungen auf deutschen Feuerschiffen." Ann. Meteorol., **7** (5/6): 267–86. Hamburg, 1956.

SOUTHGATE, B. A. "Synthetic detergents and the treatment of water and sewage." Nature, **178** (4525): 118–9. London, 1956.

ZENKEVICH, L. "Biological appraisal of the ocean, and the problem of transoceanic acclimatisation." Pap. Internat. Techn. Conf. Conserv. Living Resourc. Sea, Rome, 18. April to 10. May, 1955: 127–44. New York, 1956.